Let it rain?

Assessing the effects of rainfall variability on violent conflict

Stine Marie Ruud

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Department of Political Science

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Stine Marie Ruud

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1 Introduction

> *”Climate change is (…) a threat to peace and security. Changing patterns of rainfall, for example, can heighten competition for resources, setting in motion potentially destabilizing tensions and migrations, especially in fragile states or volatile regions”* - Kofi Annan (UNEP 2006)

These concerns have entered the political stage with full power over the past few years. In 2007, the UN Security Council held its first ever debate on climate change and its implications for security (Theisen et al. 2010), sending out strong signals regarding the ramifications climate change may have. Some have even gone as far as to call climate change the mother of all security issues (Brown et al. 2007: 1141). This thesis offers an assessment of a narrower branch of this issue; how rainfall variability affects violent conflict.

While no violent conflict can be attributed to one single cause alone, a growing number of scholars suggest environmental factors as having a significant causal role in conflicts around the world (Barnett and Adger 2007; Burke et al. 2009; Homer Dixon 1999; Kahl 2006). Debates on how environmental degradation and resource scarcity can lead to conflict dates back about two centuries, to the writings of British political economist Thomas Malthus, but seem to increasingly have gained interest over the past few years.

In recent years, the most popular new component to the environment – conflict debate seems to be that of climate change. Climate change is believed to be a result of human activities especially linked to industrialization and the burning of fossil fuels (Le Treut et al. 2007: 115), and it manifests itself through changes in precipitation, rising temperatures and the intensification of climatic natural hazards like for instance storms and flooding (Bernauer et al. 2010: 4). In the very core of several climate related hazards, lies water. Water is a vital resource; not only as a direct source of life, but it is also a necessary component in agriculture, that for many people in developing countries is both a source of food and of income (Theisen et al. 2010: 2). Changes in precipitation patterns may then cause enormous social disturbances in areas that are heavily dependent on vulnerable, rain fed agriculture. In addition, changes in rainfall are associated with extreme weather events such as storms, flooding and landslides. These pose additional challenges on human societies, especially on people living in areas that are particularly vulnerable to climate change due to for instance low levels of infrastructure and development. To conclude that climate change poses a severe challenge on human societies, however, is not to say that climate change increases conflict risk.

In spite of the increased focus on the threat climate change may be to peace and stability – as materialized through for instance the awarding of the Nobel peace prize to the International Panel on Climate Change in 2007 – this link has yet to be fully supported by research. There seems to be a divide between the qualitative and quantitative branches studying the climate change - conflict nexus; qualitative researchers are in general more confident of the existence such a link than the scholars applying quantitative techniques. For although various empirical studies have found both full and partial support for such a connection (Hauge and Ellingsen 1998; Miguel et al. 2004; Burke et al. 2009), a majority of the studies have not (Theisen 2006; Keavane and Grey 2008; Bernauer et al. 2010; Buhaug 2010). Arguing that this inconsistency could be a result of how climatic indicators are measured, this thesis takes a closer look at this question.

Rather than looking at climate change as a whole, the focus here is on rainfall variability. Rainfall patterns provide a good measure of climate change in being directly linked to the observed global warming, and by affecting human societies through extreme weather events, and perhaps most importantly: through vital resources.   While many of the contributions in this literature have studied the link between rainfall and conflict, no conclusive evidence of such a relationship has been found. I argue that this lack of coherence in results may in part be caused by the independent variables used in some of these studies. It seems a popular approach to look at annual measurements of rain, and use the inter-annual changes as a measurement of rainfall variability, measuring weather rainfall increases or decreases from year to year. Many such studies use as a point of departure that climate change is expected to create drier weather conditions, decreasing agricultural productivity, and that this again can lead to conflict under certain circumstances. However, it is not just the lack rain that affects resource availability, extreme rainfall too can have devastating impacts on agriculture (Theisen and Buhaug 2010). If one is to follow Malthusian logic and assume that a decline in resource availability may cause conflict, then rainfall variability should not be limited to lack of rain and drought. A lot of rain in a short period of time can be equally destructive for agriculture and other natural resources. It can pollute the drinking water, and flood the land (Hendrix and Salehyan 2010). Through rapid onset events like flooding and landslides, rainfall extremes can also take its toll on infrastructure leaving people in additional distress, thus backing arguments stressing how extreme weather events may increase conflict risk (see Brancati 2007). For this reason, I believe it is meaningful to capture all sides of rainfall when assessing the potential relationship between rainfall variability and conflict. It is not just the annual amount of precipitation that is important to asses, but rather the amount *and* the timing.

The general research question motivating this thesis is:

Do rainfall extremes affect violent conflict, and if so how?

In answering this question, a first step is to identify what climate change is, and the possible causal connections between this and conflict. Because of the aforementioned gap between the theoretical reasoning and the empirical evidence – both a theoretical and an empirical background for the hypothesised link will be provided. These lead to three specific hypotheses that will be empirically studied. Unlike previous studies, one of the underlying arguments here is that rainfall extremes, both negative and positive, can affect conflict risk. This provides a justification for this thesis in the broader debate.

The geographical focus will be on Sub Saharan Africa, and in particular the eastern parts of the continent. Holding less historical responsibility for human induced climate change than any other part of the world, it is a paradox that Africa is the first to be affected by the negative consequences of climate change (Boko et al. 2007). This is due to a combination of factors, including the relatively high dependence on agriculture, high environmental vulnerability, and low adaptive capacity (ibid; Theisen and Buhaug 2010). When it comes to rainfall patterns, the eastern parts of the continent seem to follow a different trend than the rest of Africa, experiencing more rain on average rather than less (Schreck and Semazzi 2004), and as a result this region will be of particular interest in this thesis – providing a good environment for studying the potential effects of too much rain on conflict.

Before going into detail about climate change and its consequences, I will narrow down the security concept, showing that it is meaningful to place this thesis as a small component in the broader climate change – security debate. Security as a concept, in its broader form, has grown to entail much more than being secure from war and violent conflict, yet war and violent conflict are still in the very core of security.

1.1 Security

As mentioned, this thesis places itself in a narrower branch of the general climate change – security debate. In the study of politics, international relations and peace and conflict, the word security has traditionally referred to national security. Securing state sovereignty has long been considered the main purpose of a state – defending its territory and keeping its citizens safe from *external* threats. As the world has gotten smaller, and liberal and humanitarian concerns have made their way all the way in to the realm of international politics, this has also changed how security is defined and how states consider it (Dokken 1997:69) . National security IS still very much a primary concern for the world's states, yet how this is understood has perhaps changed. At the same time, wider definitions of security have begun to enter the political stage. *Security* no longer denotes state security alone, but also individual security. Furthermore, the idea of what it is we seek to stay secure form has also changed. Not only external threats, but also internal ones are a concern to state security. This way, civil wars are seen not only as a threat to individual security, but also potentially to state security.

The term *human security* dates back to 1994 and the UNDP human development report, although the idea of a more human focused approach to security dates back much further (Kerr 2007: 92). The report states:

> "*Human security can be said to have two main aspects. It means, first, safety from such chronic threats as hunger, disease and repression. And second, it means protection from sudden and hurtful disruptions in the patterns of daily life-whether in homes, in jobs or in communities*" (UNDP 1994: 23).

I will argue throughout this thesis that climate change may indeed affect both these aspects; especially in the developing world. As I will demonstrate, climate change *can* undermine human security. What is less clear is how this human insecurity leads to violent conflict (Barnett and Adger 2007). When the United Nations Security Council (UNSC) discusses climate change as a potential security threat, it shows that the possible security ramifications of climate change go beyond those of individual, human security.

Throughout this thesis I will refer to this difference as security in the broad and narrow sense. Violent conflict, that will be in focus here, is still within the realm of the narrower, traditional security concept – where national security, power politics and war are keywords. Hence violent conflict is used as an expression for traditional security concerns. When I on the other hand refer to a broader notion of security, this encompasses other security concerns, especially human security; where the referent is the individual rather than the state. Human security is an important part of the climate change – security debate, but this is not the security concept in focus here. What this thesis seeks to explore is how climate change may be a threat to security in the narrower, more traditional meaning of the word, through increasing conflict risk.

2 Climate change

2.1 Climate change and its causes

Increasingly on both the local and international political agenda, climate change has become a well-known concept; with the focus that politicians, scientists, the media, humanitarian organizations and a wide array of others give to the climate change debate, it has indeed become difficult to overlook. There are three main levels in this debate. First of all, the climate change debate evolves around if and how much the climate is in fact changing. In spite of a few sceptics still questioning the factuality and severity of climate change, evidence has long ago convinced most that climate change is real. With a temperature increase that in the past century alone stands for a roughly 7 to 12 % of the total change in the last 18000 years or so (Homer Dixon 1999: 60), it seems easy to conclude that something extraordinary is going on. Related to the increasing temperatures, climate change also manifests itself through changes in precipitation, more unpredictable weather and an intensification of climatic natural hazards like for instance storms (Bernauer et al. 2010: 4). Due to the amount of evidence indicating an actual change in the climate, the debate has shifted focus in the recent years from whether the climate is changing, to whether the observed changes can be attributed to human activity (Gartzke 2010: 3).

Secondly, then, the debate also includes a causal aspect, regarding human activities role in the observed changes. The causes of climate change are not as easy to identify as its factuality, yet there seems to be a general consensus that human activities do play a central role in the observed changes, although some few still believe that these changes are just part of the natural cycle. The International Panel On Climate Change (IPCC) has the function of collecting and objectively reviewing serious research on climate change and its physiological and biological effects from scientists all over the world, and is perhaps the most important source laying the premises for the climate change debate (Nordås and Gleditsch 2007: 629). In the IPCC fourth assessment report it is clearly stated that it is very likely, defined as from 90 to 99 % certain, that climate change is at least partly human induced, or put differently; that it is *extremely unlikely* (<5%) that the global pattern of warming observed during the past half century can be explained without external forcing (Solomon et al. 2007: 86). This human activity is often linked to the blooming of industrialization over the past century, that have led to a significant increase in carbon dioxide emissions primarily from the burning of fossil fuels, at the same time as extensive deforestation. This has created excess in greenhouse gases, which again warms up the earth (Le Treut et al. 2007: 115). This warming has a strong causal role in other observed climate change indicators too, like more extreme and unpredictable weather, and changes in precipitation patterns (see Schreck and Semazzi 2004, Boko et al. 2007).

While it is difficult to establish the *exact* role human activities play in the observed changes in the climate, this is not important for the purposes of this thesis. The focus here will be on the third level of the climate change debate, namely the consequences of climate change. It should therefore be sufficient to note that there is little doubt among scholars that human activity over the past century or so is one of the drivers of the observed climate change, and this is attributed mainly to the aforementioned industrialization and emissions of fossil fuels.

Also the consequences of climate change are difficult to establish exactly. Isolating the effects that climatic factors have on the natural system, or even worse; on human systems, is no easy task. Still, changes in temperature, precipitation and the frequency and strength of natural hazards are bound to have an effect on the environment, and there is a general consensus on some of these effects.

2.2 Environmental effects

The natural environment can be very vulnerable to the factors associated with climatic change. Most people that have ever dealt with a plant would know that both the temperature and the correct amount of water are crucial for the plants survival. Give it too much water, and the plant will die. Give it too little water, and the result is the same. The same logic is of course valid for the natural environment, and changes in the climate will also lead to environmental changes. In much of the literature a distinction is made between slow onset and rapid onset environmental changes (NRC 2009, Brown and McLeman 2009: 293).

What is commonly referred to as slow onset natural changes, means alterations in the natural environment that forms over time. These include drought, desertification and sea level rise. Climatological factors like warming can cause several such slow onset changes. Higher average temperatures have for instance caused large changes in the cryosphere, the part of the planet where water is in solid form. The cryosphere on land stores about 75% of the world's freshwater (Lemke et al. 2007: 341). These changes include a decrease or melting of permafrost, permanent snow covers like that of mount Kilimanjaro, ice caps and glaciers. The two latter have contributed to sea level rise that threaten biological systems – and human societies – in coastal zones. While the average sea level rise has been 1.7 to 1.8 mm per year in the last century, this number has drastically jumped to a 3 mm per year in the last ten years (Rosenzweig et al. 2007: 92). This has huge implications for coastal zones where the rising level of the oceans is threatening to flood cultivable land and make large stretches of what is today habitable coastal land inhabitable. Underwater ecosystems too are increasingly at risk, for instance through the bleaching of coral reefs and decline in fish stocks. This is mainly due to warming of the oceans, but in some places the under water ecosystems are also being disturbed by an increasing freshening of the seas; a result of polar ice melting.

Terrestrial biological systems are suffering the consequences of climate change as well. Both changes in temperatures and changes in rainfall patterns can have devastating effects on fragile ecological systems. It has been estimated that with a temperature increase of only 1.5 – 2.5 degrees, up to 30 % of the worlds plant and animal species will be at increased risk of extinction (Buhaug et al. 2008: 8). Africa has a variety of different ecosystems, from rainforests to desert, which are all vulnerable to changes (Boko et al. 2007). Among the concerns are especially increased drought, desertification and the loss of fertile land and as an effect; both plant and animal species. Additionally, rising sea level pose a direct threat to coastal zones and especially small island states (see Kinnas 2005), not only through the flooding of cropland and other terrestrial biological systems, but also to the extent where some island states may actually be at risk of eventually being lost to the sea.

Often associated with extreme weather events, rapid onset natural changes come suddenly and often unexpectedly. These are both in themselves extreme weather events, such as storm, and the consequences of extreme weather, like flooding, and are associated with what is commonly referred to as natural disasters. According to a recent report from the Norwegian Refugee Council (NRC 2009: 5), the number of recorded natural disasters has doubled from about 200 to over 400 per year over the past 20 years. Flooding as well as landslides is often a result of heavy rain; making precipitation patterns central in causing rapid onset natural hazards, as well as the aforementioned slow onset ones. Flooding for instance is often more common where periods of drought are followed by heavy rain. In these cases, the dry land is unable to absorb the water, which may contribute to the severity of the flooding. Both flooding and landslides can leave large areas uncultivable, and may also destroy infrastructure.

2.3 Social effects

There are several severe social consequences of these environmental changes – and it is these that are the hypothesized connecting link between climate change and violent conflict. First of all, rapid onset natural changes - landslides, storms and flooding -can pose a direct threat to human lives. Every year thousands of people die as a direct result of natural disasters, and millions more are affected. At the time of writing, a flood in Pakistan has left at least 1200 people dead, with another 6 million affected to the point where they are in acute need of food, shelter, clean water and healthcare (UN 2010). Just in 2010, deadly landslides have been reported from China to Uganda and Mexico, demonstrating the global reach of weather related tragedies.

The second major social effect can also be lethal; a potential decrease in clean water accessibility. According to UNESCO, 340 million people in sub Saharan Africa lack access to clean drinking water (Hendrix and Salehyan 2010: 2), and with more widespread extreme weather this number is threatening to increase. In some future scenarios, the predicted number of additional people in risk of water stress in Africa by 2020 is between 75 and 200 million (Boko et al. 2007: 445).

Thirdly, a decrease in agricultural productivity because of destruction of cropland, can seriously affect another vital source of life: food. In 2004, 230 million people were undernourished in Africa alone (Brown and Crawford 2009: 16), reflecting that the need for an increase in food production and distribution is massive. In addition to fresh water for drinking and household use, water is a critical input for agriculture and industry (Hendrix and Salehyan 2010: 1), and hence for food production.

This decrease in agricultural productivity also affect peoples livelihood (Buhaug et al. 2008**)**. In some African countries up to 70 % of the population live off the land, and many will have difficulties in finding other sources of income. Climate change may in other words exacerbate poverty. Clean water is also key to parts of the industry, especially manufacturing. A decrease in productivity, both in agriculture and manufacturing, poses serious challenges for economic productivity, not only on an individual level but also on a national and regional level. Agriculture represents between 20 and 30 % of GDP in sub-Saharan Africa, and make up 55 % of the total value of the export (Brown and Crawford 2009: 10).

A decline in food production can lead to both malnutrition and hunger, and lack of water and dehydration is lethal. But human health can be affected by climate change in other ways as well. When it comes to diseases in Africa, in addition to HIV/AIDS, malaria is one of the largest threats to human lives. According to the World Health Organization (WHO), malaria stands for about 20 % of child deaths in Africa, with one child dying from the disease every 45 seconds (WHO 2010). In parts of East Africa, the documented incidents of malaria have increased since 1970. For instance in Kenya, the malaria vectors seem to have spread to the highlands that were malaria free only 20 years ago (Rosenzweig et al. 2007: 108), a human tragedy that is attributed to changes in both temperature and precipitation. Furthermore, lack of access to freshwater as a result of both sea level rise and heavy precipitation (Easterling et al.

2007: 298) can spread deadly diseases like cholera, as seen in the aftermath of the devastating earthquake in Haiti in 2010.

Also the destruction of infrastructure, mainly from rapid onset events, has its social implications. Where thousands of people lose their homes at the same time, even if only temporarily, it is easy to argue that these circumstances may nurture despair, large migrations, and an intensified immediate competition over both shelter, food, limited on-scene medical care, and in the long run also jobs (Reuveny 2007).

2.3.1 Vulnerability

While climate change may definitely contribute heavily to the abovementioned social challenges, it cannot be seen in isolation from other factors. A natural hazard becomes a natural disaster when it has severe negative impacts on human settlements. When the infrastructure and general degree of development is low, a relatively small storm can cause great damage. Both slow and rapid onset disasters vary in severity depending on where they take place. As Barnett (2003: 5) notes, if it was only about biophysical risk, Japan would be as vulnerable to climate change as Papua New Guinea. The social effects of climate change are thus not caused by climate change alone, but are also linked to vulnerability. IPCC has defined vulnerability in this regard as a combination of three interrelated elements: exposure, sensitivity and adaptive capacity (Kinnas 2005: 5). While exposure denotes the degree to which one is affected by the purely physical impact of a changing climate, the two latter refers to how resistant a society is to the negative effects of these natural phenomena. Put simply, level of sensitivity determines the degree of damages, and adaptive capacity how well the society is able to adapt to the negative effects.

Since Africa has played a small role in the human driven causes of climate change, it is a paradox that the continent is the most vulnerable to its effects. This is because of the multiple stresses and the generally low adaptive capacity (Boko et al. 2007: 435, Brown et al. 2007: 1145). These multiple stresses, that determine the degree of sensitivity, often concern pre-existing environmental degradation, low levels of socioeconomic development, and political instability. Especially in Sub Saharan Africa, poverty is widespread, and millions of people are already suffering from water stress, malnutrition and other struggles that can be directly linked to the environment (Brown and Crawford 2009). The low level of economic prosperity and development also put strains on the continents adaptive capacity, making them even more vulnerable to extreme weather events and the negative social effects of climate change. Together, these factors can lead to disturbances in human settlements on a large scale. Of special concern is how this can contribute to mass migrations. According to the IPCC fourth assessment report, 150 million people may be displaced in the context of climate change by 2050 (NRC 2009: 6). The argument is that a decline in access or availability of vital resources put pressure on people and leads to intensified competition over the remaining resources. If large areas of what is now relatively fertile land are damaged by drought, flood or other hazards, this may force millions of people to relocate, which again will put more stress on the host communities (see Reuveny 2007). It is for these unfortunate reasons Africa is a preferred subject of analysis in this study field; because of the continents relative vulnerability to climate change, it is likely to provide more answers regarding the climate change– conflict nexus than any other part of the world.

I have thus far focused on what climate change is, and what the consequences are. I will now shift focus to show how climate change can be related to conflict through the social effects mentioned in the previous section, and provide a theoretical and empirical framework for the assumptions that will be tested later on. The following section offers an assessment of how rainfall may affect stability and conflict, and posit three specific hypotheses regarding this relationship. Then, the dataset and statistical methods will be presented, before carrying out the statistical analyses and discussing the findings.

3 Relating climate change to conflict

3.1 Theoretical perspectives

The previous section leaves little doubt that climate change, through natural hazards and environmental changes can have significant negative impacts on human beings, both at the individual and societal level. It even remains clear that climate change can in fact undermine human security, through posing a direct threat on human lives. Yet that is not to say that it is a significant contributor to conflict.

When it comes to making the link between environmental degradation and conflict, the idea is by no means a new one. The environment – conflict debate has been going on for at least two centuries already, and hence dates back to long before climate change was on the political agenda. Although there are different perspectives regarding the causal mechanisms leading from environmental factors to violent conflict, the main argument is that environmental factors affect resources on which humans depend, which again intensifies competition over resources and triggers human reactions that increase the risk of conflict.

This argument is in line with the neo - Malthusian perspective, that base its ideas on the theoretical legacy of Thomas Malthus, a British economist whose writings date back to the late eighteenth century. His main argument was that exponential population growth would eventually lead to a greater demand than supply in food production, meaning that the planet would no longer be able to provide for human needs (Kahl 2006: 4, Homer Dixon 1999: 29). Under certain circumstances, the increased competition that arises over the remaining and scarce resources could lead to violent conflict.

For the purposes of this thesis, there are mainly two ways this can happen in accordance with the neo Malthusian view. The *deprivation hypothesis* argues that population growth, environmental degradation, and an uneven distribution of resources produce relative deprivation among the poor. As competition for natural and economic resources increases, so does the risk of violence (Kahl 2006: 9). The *state failure hypothesis*, on the other hand, claims that this only happens when the state is too weak to prevent the deprivation from turning in to conflict. Strong states will often be able to stop this from happening either through providing relief for aggrieved individuals, or through coercion (ibid: 10). In this view, organized violence is only likely when environmental degradation and population pressure are combined with a weak state. If the system is able to at least partially meet the demands of deprived citizens, the chances of violence and conflict is believed to decrease.

As a leading scholar in the environmental scarcity literature, Thomas Homer Dixon, has a central role in this debate. Together with the Toronto group[1], he has conducted numerous studies regarding resource scarcity and violent conflict (see Homer Dixon 1991; 1994; 1999). Homer Dixon divides environmental scarcity into three categories; supply induced scarcity, demand induced scarcity and structural scarcity (ibid 1994). The first category refers to the cases where resources degrade faster than they are renewed, and the second one to cases where the demand for resources increase faster than the supply, especially altered by population pressure. The third category applies where the resource in question is concentrated in the hands of a few, typically the elite, while the rest of the population are experiencing resource shortages; in other words an unequal distribution of the resources (Homer Dixon 1999: 15).

Especially the first category is important for my purposes. The reason for this follows a pretty straightforward logic; rainfall is directly linked to the supply of natural resources, while the two others are more determined by social factors. It is the supply-induced scarcity that is closest related to environmental change (Homer Dixon 1999: 8).

The three sources of scarcity do interact however, and the two other categories are not isolated form environmental change. For instance can demand-induced scarcity be a by-product of environmental change. The issue of so-called eco migration and climate

[1] A common name for the group of conflict researchers at the University of Toronto, in which Homer Dixon is a central figure.

refugees is one of the primary concerns in the climate change – security debate. The logic behind this concern is that as the problems originating in the competition over resources intensify, people will migrate en masse in search of better opportunities elsewhere. Reuveny (2007) argues that this eco-migration can put so much additional stress on the host areas i.e. where the environmental migrants arrive, that it can increase the risk of violence here as well, through the same mechanisms of resource competition. This is supported by the findings of Gleditsch and Salehyan (2006), indicating that refugees from neighbouring countries increase the risk of conflict. Hence following the argument of Reuveny, environmental problems that might at first glance seem local can easily spread and lead to similar problems in neighbouring communities. Reuveny`s case study of the aftermath of Hurricane Katrina shows that most of the people that were forced to leave, had at the time of writing in 2007 still not returned to their homes, showing that migration from extreme weather events is not just a short term trend. The potential effect this has on conflict is likely to be more prominent in less developed countries – a presumption that is also backed by evidence from his case study of Bangladesh (Reuveny 2007: 5).

Structural scarcity, on the other hand, refers to a context where there is a severe imbalance in the distribution of wealth and of access to resources, and this imbalance often has its roots in class and ethnic relations (Homer Dixon 1999: 15) . It is possible to imagine that structural scarcity too is influenced by the supply of a resource, but with the competition over resources being between the elite and the rest, rather than between groups, and where the elite ensures its own survival effectively blocking the access of others to the resources. A related example is found in a study of the Middle East, where one of the concerns is that environmental degradation will lead to increased militarization with armed military guarding for instance water wells (Brown and Crawford 2009b). It should be noted that although Homer Dixon is clear in his view that climate change *can* lead social disturbances on a large enough scale to cause violence and conflict, he does not believe that climate change *alone* causes this. It is only in combination with social factors that climate change becomes a security risk.

Despite their prominent position in the environment – conflict debate, neither Thomas Homer-Dixon nor the neo Malthusian perspective in general has gone un-criticized. The opponents hold that the causal mechanisms proposed by the neo Malthusians are too elaborate, that the supporting literature tends to draw its conclusions based on case studies that are selected on the dependent variable, and that the perspective all in all is too pessimistic (see Urdal 2005; Nordås and Gleditsch 2007; Hendrix and Glasner 2007).

Differing from the Neo Malthusian view, neoclassical economists often assert that it is resource abundance rather than scarcity that creates social instability (Kahl 2006: 14). Scholars supporting this view argue that states are able to adapt to this resource scarcity, and question the argument that population growth and environmental degradation necessarily leads to resource scarcity. Compared to the neo Malthusian perspective, neoclassical economists are far more optimistic when it comes to the effects population growth can have on society.

As the name indicates, this perspective focus attention on economics, and draws inferences about the resources - conflict link by emphasizing the economy of resources. But simply, it is about *greed* rather than grievance (Kahl 2006: 15). According to the *honey pot hypothesis*, abundant supplies of valuable natural resources create incentives for conflict groups to form, and to fight in order to capture these resources; profit seeking motivates and empowers insurgents in resource rich countries (ibid). In a different manner, the *resource curse hypothesis* blames the tendency especially developing states have to rely too heavily on the export of natural resources, thereby tying their economy too much to a fragile and volatile market. Not only does this leave the national economy extremely vulnerable to shifting trends in the international market, concentrating both capital and labour in one sector, but it also undermines other economic sectors important to the society (Kahl 2006; Homer Dixon 1999). An often-mentioned example of economic sectors that suffer from this over reliance on the export of resources is labour intense manufacturing, which is of particular importance to many developing countries. It is when the prices of the commodity drop and markets "crash" that the social effects believed to increase the risk of conflict can become prominent.

These views, however different they may seem, are not necessarily contradicting. They can in fact coexist (Urdal 2005: 419). Renner (2002: 9) argues that environmentally induced resource scarcity first and foremost concerns resources that cannot easily be traded. Although, as mentioned, agriculture stands for about half of Africa's export, I dare to argue that the neo classical economist arguments are more valid for resources like diamonds, gold and coal, due to the quantity – worth ratio on these relative to agricultural goods. Neo Malthusian perspectives on the other hand, mainly focus on resources covering basic needs (Hendrix and Salehyan 2010). This leaves the neoclassical economist view more applicable to lucrative resources associated with wealth, and the neo Malthusian perspective more applicable to natural resources directly linked to food production. Although the neo Malthusian perspective is not a main focus of this thesis then, it is nevertheless difficult to avoid that many of the arguments here will follow the same line of thoughts as those belonging to neo Malthusian literature, since the type of resources that are likely to be affected by rain are those central to this view.

The distinction between these theoretical perspectives, although not necessarily contradictory, nevertheless provides a good theoretical background for the empirical literature.

3.2 Empirical background and hypotheses

In the numerous empirical studies on the climate change – conflict link, theory does not always have a central role. The quantitative literature is driven more by empirical than theoretical background, which may not be all that strange since they are after all empirical studies. Yet this means that perhaps unlike in many other branches of social sciences and political science, there are no clearly outlined *theories* driving the debate, but rather a combination of underlying theoretical assumptions linked to the literature mentioned in the previous chapter, discipline affiliation, and methodological preferences.

While the theoretical assumptions regarding the influence of the environment on conflict are well embedded in literature, the empirical evidence in this field is far from convincing (Salehyan 2008). There seems to be a divide between the empirical, quantitative literature and qualitative case studies when it comes to findings. The non-statistical studies in this field do for the most part agree that climate change should be seen as a security threat, and that it has had, or will in the future have, a direct and significant influence on conflict. This branch of the literature consists both of case studies (see Homer Dixon; Kahl 2006; Brown and McLeman 2009, Reuveny 2007) and of reports based on other studies, aiming to warn about future effects (see Brown and Crawford 2009b, Barnett and Adger 2007, Buhaug et al. 2008). The problem, however, arises when attempts are made to statistically support these links.

3.2.1 Rainfall and conflict

In the quantitative, statistical literature, the findings regarding the link from environmental factors to violent conflict are inconclusive. This inconclusiveness can be partly due to the fact that the very nature of this type of study assumes a simplification of reality and may overlook important mechanisms. Different outcomes in the various analyses is also closely related to operationalization and measurement. In the wider context of the debate, both climate change and security, or even conflict, are difficult concepts to clearly define and operationalize. This entails that the related literature encompasses a variety of studies measuring slightly different mechanisms. Only small differences in design in terms of aggregation level and measurement seems to give very different results. Among the studies of so called slow onset environmental changes, there are mainly three explored paths from climate change to conflict; through neo Malthusian indicators of scarcity, through testing climatic parameters directly, and through economic indicators.

Slow onset:

Much of the slow-onset literature assesses the neo Malthusian scarcity – conflict nexus. In 1998, Hauge and Ellingsen conducted one of the very first large N studies in this study area. Looking to test the model of Homer Dixon, they applied typical neo Malthusian indicators like land degradation and low freshwater availability to determine the impact these had on conflict. Although they found economic and political factors to be more determining than environmental factors, their results did show that countries experiencing environmental degradation were more prone to conflict (Hauge and Ellingsen 1998). Yet despite the pioneering status of this research, it was a few years later shown that their study was not replicable (Theisen 2006). Theisen was not only unable to replicate the study, a serious blow to the reliability of the Hauge and Ellingsen study, but when he used his own data to test the same hypotheses, he found very little support for these (ibid). This is consistent with findings from similar studies as well. Urdal finds some evidence of increased conflict where land scarcity combines with high population growth, but these results are not very robust (Urdal 2005). Raleigh and Urdal (2007) too look typical neo Malthusian factors like freshwater availability, land degradation and population density to see how these affect conflict. The study is one of the first to look at these factors on a sub national level rather than a country level, yet their findings too are somewhat inconclusive. While their results indicate some effect from the environmental and demographic indicators on conflict, the impacts are far outweighed by economic and political factors.

To be able to identify the effect of the environment, and especially climate change, on conflict, going via resource scarcity may not be sufficient. As seen from the different social effects climate change can have, resources are undoubtedly an important component, yet can not alone bear the entire argument of a potential link between climate change and conflict. Several of the typical neo Malthusian measures are not exogenous to human activity (Bernauer et al. 2010: 15), hence these indicators do not only capture climatic conditions. Several other studies test climatic variables more directly, without going through indicators of scarcity. The most popular hypothesis in this regard seems to be that decreased rainfall and drought will increase the risk of conflict, which often takes the shape of civil war. One study that combines this with what they term long term trends, referring to what I have named neo Malthusian indicators like land degradation and freshwater availability, is that of Hendrix and Glasner (2007). Both for these indicators, and for their trigger variable rainfall, they find a significant impact on conflict, albeit not in the absence of economic and political variables. This is consistent with the notion of vulnerability as a key aspect to understanding the effects of climate change. Finding the trigger variable to be of higher significance than the trend variables, the authors conclude that their findings indicate that drier years increase the risk of conflict. Consistent with this, Levy et al. (2005), whose research is on a global scale, but sub national level, show that the likelihood of high intensity conflict is higher in years following a year with rainfall levels significantly below normal.

These findings however are not representative of the general findings in this literature. Arguing against those who have blamed the crisis in Darfur on environmental degradation and drought especially, Keavane and Grey (2008) find no evidence of such a correlation for the breakout of conflict in Darfur in 2003. Rather, they argue that since there was no sign of decreased rainfall in the years prior to 2003, drought and lack of rainfall could not have been contributing factors to the conflict. In a recent study Buhaug and Theisen (2010) also test if drought is associated with civil war risk among African states, using a selection of parameters of precipitation (Buhaug and Theisen 2010: 9-10). Their analysis does not uncover any relationship between rainfall, or drought, and conflict risk. The same authors, this time with a little help from a friend, also look for any potential impact of drought on conflict on the sub national level. Using much of the same or similar data, but with a spatially disaggregated dataset for Africa, does not help the conclusion. Again, their study fails to uncover any such relationship, concluding that the causes of civil war are political rather than environmental (Theisen et al. 2010). Could they be looking at the wrong indicators of climate change? Burke (et al. 2009) finds temperature to be a more robust measure than precipitation, and that warming does indeed increase the likelihood of civil war in Africa. These findings uncover that precipitation and temperature are negatively correlated, which according to them may indicate that studies looking at drier years partially capture the effects of warmer years (Burke et al. 2009: 20672). Yet this conclusion is not necessarily correct, at least not in the case of east Africa. Schreck and Semazzi (2004) have found a dipole pattern in Africa in ENSO (El Niño – Southern oscillation) induced rainfall anomalies (ibid: 682). It seems that the eastern parts of the continent experience an increase in rainfall in response to warm ENSO events, with the opposite pattern for the rest of Africa. If this is true, then it could be that, at least in east Africa, warmer years and drier years do not correspond. Their findings furthermore indicate that east African rainfall is consistent with global warming, meaning the region may experience an increase in rainfall as the average temperatures rise. This is supported by other studies as well (see Hulme et al. 2001). In the case of east Africa then, climate change could mean more rain rather than less, making the latter alone an inadequate indicator if we want to see how climate change affects conflict in this region.

Although for slightly different reasons, Buhaug (2010) too disagrees with the conclusions of Burke et al. (2009). He has conducted a follow up study criticizing especially the dependent variable used by Burke et al. The indicator of conflict used in the original study is limited to civil wars with a thousand or more battle deaths, which leaves out smaller, but significant, conflicts. Changing their original dependent variable to encompass smaller armed conflicts as well (25 battle deaths), and adding some to their climate parameters, Buhaug once again finds other explanations of civil war to be more valid than environmental ones. He argues that civil wars in Africa can better be explained by structural and contextual conditions including political exclusion and poor national economy, yet his findings do show vague indications that major civil wars are more frequent in years following unusually wet years (Buhaug 2010: 8). Given that there such a pattern is correct, then this is perhaps in line with what we might expect in the East African context.

Burke et al. s study emphasises the role precipitation have in livelihood in Africa, and argues that it seems likely that variation in agricultural performance is the central mechanism linking warming to conflict (Burke et al. 2009: 20672). This is related to a range of studies that assess the effect of climate change by going via economic factors. The general argument is that, especially in the African context, income and economic growth is closely correlated with weather shocks, due to the importance of agriculture to the economic sector. Bernauer et al. (2010) seek to find out if climate change increases the risk of conflict, via economic growth. While the study does suggest some negative effects from climate change indicators on economic growth, and strong economic growth to have a negative effect on conflict, their results reflect the general observation in this literature: the effects are too weak and the findings are too vague to fully support the hypothesised impact of climate change on conflict. Years earlier however, in 2004, one study did find support for a similar view. Using rainfall shocks as an instrumental variable for economic growth, the infamous study of Miguel et al. found this to have strong significant influence on conflict. This much-cited study found that negative growth of rain increased significantly the risk of conflict in the following year, also indicating that more rainfall makes civil conflict less likely (Miguel et al. 2004: 737). As many others have hypothesised then, their findings indicate that drought increases the likelihood of conflict. Yet as the equally renowned work of Hauge and Ellingsen, and that of Burke et al., their study have been victim of failed attempts of replication. Ciccone (2010), strongly, and as I will argue; correctly, reacts to the way Miguel et al. measure rainfall. As many others, they measure precipitation patterns as change from the previous year, i.e. as annual growth. This approach has serious limitations. Because rainfall levels are strongly mean reverting, low growth need not reflect that current rainfall levels are low (ibid: 2). If one year experiences a strong increase in rainfall, then the next year can be measured with low or even negative growth even if it still rains more than average, given that it rains less than the previous year. When using the data from Miguel et al., Ciccone finds that if anything, the opposite of their conclusions is true in their data; conflict follows positive shocks, not negative ones (ibid). Hence operationalization and different causal paths seems to determine to what extent the various findings support the notion of climate change as influential in conflicts. When going via economic shocks, this literature assumes an indirect link that is highly dependent on other factors. What studies like that of Bernauer et al. (2010) for instance, really fail to find is an effect from rainfall to economic growth.

I further argue that an additional problem in the approach used by Miguel et al. (2004), and several others, is that their measurement of the climatic parameter rainfall does not capture intra annual extremes. As mentioned, changes in precipitation are related to both slow and rapid onset natural changes, and I strongly believe that they both need to be accounted for when we assess the impact climate change and especially rainfall have on conflict

Rapid onset:

I argue in this thesis that rainfall is a good indicator of climate change, among other reasons because it can be directly linked to both slow and rapid onset natural changes. Although a less explored field, some scholars have also specifically studied the relationship between rapid onset changes, understood as natural disasters, and conflict. Brancati (2007) conducts a statistical analysis of earthquakes in 185 countries, and her findings suggest that these can stimulate intrastate conflict by producing scarcities in basic resources. Although it is less certain that earthquakes are linked to climate change than is true for many other natural disasters, her arguments about rapid onset disasters are still valid here. The logic is intuitive; in occurring quickly and without warning, rapid onset disasters are more likely to provoke acute feelings of frustration arising from relative deprivation than those linked to slow onset changes, such as droughts (Brancati 2007: 716). Her arguments can be seen in connection with the neo Malthusian deprivation hypothesis, since existing inequality in the distribution of resources is likely to be exacerbated in these situations. Of course, like with other environmental issues, the social consequences of disasters like earthquakes are often worse in areas where the general level of development is low. This is also in sync with her findings. A main mechanism in the potential relationship between rapid onset disaster and conflict is also that of intensified competition over resources. This is closely related to the neo Malthusian argument, but is valid for a broader spectre of resources than just the renewable natural ones. In cases like those seen recently in

Pakistan and Haiti, where rapid onset disasters leads to millions losing their homes simultaneously, and the access to resources like food, medicine, shelter and freshwater is rapidly depleting, it is easy to imagine how violence may occur as a by-product of the desperate situation. In the long run it is furthermore possible to imagine how this can create negative sentiments towards the government and elite, if aid has not been provided in a satisfactory manner.

Contrary to these conclusions however, Slettbak and DeSoysa (2010) find that countries with one or more disasters in the same or previous year are less likely to have an outbreak of conflict. They study the effects of a range of weather related indicators, including storms, floods, and drought, on conflict. Few of the indicators turn out significant; the only one that does is drought, reporting negative values (ibid: 19). However, drought as defined in this thesis, is not a rapid onset disaster. The natural disasters in their data that here would be defined as climate related rapid onset disasters, landslides and flood, turn out with positive signs, although not statistically significant. Hence their findings do not necessarily contradict the conclusions of Brancati (2007), yet are nevertheless too ambiguous to support them.

Summing up, it seems that just small variations in research design can make all the difference for a study's findings regarding the influence climate change has on conflict. Posing slightly different questions, or the same question in a slightly different manner, gives such different results that the empirical literature as a whole does not render much support to this hypothesized link.

We see that when rainfall has been used as an indicator of climate change, this has normally been based on the assumption that a decrease in rain, as an expression of drought, can lead to conflict. Yet the opposite may also be true. I believe both excessive rain and lack of rain can have an effect on conflict – because they both can have severe social implications. The issue with too much rain is not completely ignored by the literature[2], but it has only rarely been in focus. The fact that so many of

[2] It is included by among others Miguel et al. 2004; Hendrix and Salehyan 2010; Buhaug and Theisen 2010.

these studies have done what Ciccone (2010) criticized Miguel et al. (2004) for, namely used a year to year change in precipitation amount as an indicator of rainfall variability, makes inferences about such a link problematic. Operationalizing shocks as percent change in annual rainfall can be misleading (Hendrix and Salehyan 2010: 13). In addition, when rain is the element of interest, it is not just about amount alone, but rather about amount and timing. A variable that focus on change in yearly amount says little about the pattern of the rainfall, and extreme weather conditions like a longer dry season and a wetter rainy season will not necessarily show when this approach is being used. Heavier rain in the rainy season, for instance, may contribute to normal annual amounts being reported in otherwise dry years, and lead to failed harvest as the rain comes too late, too early or too concentrated (Buhaug and Theisen 2010: 9). An additional reason to investigate the effect of too much rain is the special pattern found in east African climate. If it is true that this region is experiencing more rain due to warming – and will continue to experience more rain in all the different future SRES scenarios [3](Hulme et al. 2001), then the effect of excessive rain too should be accounted for when studying this region.

It is my view then, that both sides of normal rainfall should be included– and that intra-annual changes as well should be accounted for – when studying the effect of rainfall on conflict. A similar approach is found in recent studies. Hendrix and Salehyan (2010) find rainfall variability to have significant influence on small- and large-scale political conflicts in Sub Saharan Africa, and argue that extreme deviations from normal rainfall patterns, droughts, and floods—which they collectively term hydro-meteorological disasters—may lead to social and political disorder. Including both excess and shortage of rain, and acknowledging the damage the first can do as well; they find a significant correlation between the hydro-meteorological disasters and conflict.

[3] SRES stands for Special Report on Emissions Scenarios, developed by the IPCC. The report has four scenario groups regarding future socio-economic and environmental development, which are used to model future climate change scenarios regarding changes in temperatures and the climate (see Hulme et al. 2001; IPCC 2007)

Based on these arguments, I formulate the first hypothesis to be tested statistically in this thesis:

H1: extreme variations in rainfall are positively correlated with conflict.

In line with the arguments leading to this hypothesis, it is expected that both negative and positive extremes may have an influence on conflict. Furthermore, it is also expected that especially positive precipitation values are associated with more rapid onset disasters, which could be more immediate in increasing conflict risk, through more rapidly creating feelings of despair. This way, *extreme variations* includes aspects of both amount and timing.

3.2.2 Rainfall and the nature of conflict

There is another side to the definitional and methodological choices in much of the climate change – conflict literature worth taking into consideration. Most studies make inferences about this link by studying mainly conflict onset. They further seem to conclude that environmental factors are, if influential at all, never the main *cause* of a conflict. Still, for the most part, the main dependent variable of these studies remains conflict *onset.* If environmental factors do not *cause* conflict, yet are still believed to *impact* conflict, it seems a logical choice to study other sides of conflict in addition to its onset. Climatic factors, even when failed to prove important for creating conflict, may still influence already ongoing ones. To draw conclusions about the influence climate change has on conflict through only consider conflict *onset*, is in my view not satisfactory.

Although not as often, similar arguments have been made. Hauge and Ellingsen explored the severity of conflict, using a continuous dependent variable measuring number of battle deaths as percentage of entire population (Hauge and Ellingsen 1998: 305). Although their findings should be interpreted with caution, they did find indications that greater land degradation and population pressure, and lower freshwater availability, increases conflict severity. Their data on battle deaths only covers major civil wars, and the study has lost some credibility due to the aforementioned failed replication (Theisen 2006). Yet the theoretical argument remains interesting.

Brown and Crawford argue that climate change could intensify land-use conflicts and trigger environmental migration by exacerbating existing environmental crises (2009: 1). Furthermore, according to the same authors, a clear connection has been identified between natural disasters and the intensification of conflict (ibid: 21). If climate change does in fact have an influence on conflict, then there is no reason why this should not be true for conflict intensification. It may in fact be argued that it should be more noticeable on conflict intensity. The threshold for the outbreak of a new conflict is arguably higher than for the intensification of an ongoing one.

As seen, the majority of the relevant literature in this field tends to focus on conflict onset. Yet to assess the causal relationship between climate change and conflict, the onset of new conflicts is not the only interesting component; the possibility that climate change may affect the nature of ongoing conflicts should also be explored

H2: Rainfall variability has more impact on conflict intensity than on conflict onset

Based on the arguments made, I expect the relationship between rainfall variability and conflict intensity to be stronger than that of rainfall variability and conflict onset; as the threshold that is likely to be present in the outbreak of conflicts does not influence intensification of existing conflicts.

3.2.3 Rainfall and vulnerability

As mentioned in section 2.3.1, climate change does not operate alone in creating the harmful effects on human societies believed to increase the risk of conflict. Not only are there several alternative explanations for the outbreak and intensification of conflict and civil war, certain social aspects are also believed to interplay with climate change and determine the strength of the effect this has on conflict. It is mainly non-climatic factors that will determine whether climate change moves from being merely a development challenge to presenting a security threat (Brown and Crawford 2009:23). There are two such factors that will be of interest here; ethnicity and vulnerability. While it can be argued that ethnicity should be seen as part of vulnerability through increasing sensitivity, for reasons of simplicity, I choose to treat this as a different component.

In the context of violence in Africa, ethnicity is often believed to play a central role (Homer Dixon 1999; Kahl 2006; Theisen 2010). This can be explained in terms of the artificial nature of African state borders. These were to a large extent determined by European powers who divided the continent between them without taking ethnic and national compositions into consideration (Henderson 2008; Easterly and Levine; Robinson 2009). Thus, African states differ form the traditional nation state, and are in general more ethnically diverse than states elsewhere (Fearon 2004). Ethnic diversity, in turn, makes nation building more difficult than it would be with a culturally homogenous group (Robinson 2009), and identities are often more linked to ethnical belonging than nationality, perhaps unlike what is common in the western world. Ethnically based political parties are common (Fearon 2004), and the importance of ethnical belonging can even be traced to the realm of foreign politics where loyalty to ethnical background is high even across state boarders (Davies and Moore 1997). The within-state ethnical diversity that arose from the sharing of the continent is also believed by some to have laid the premise for conflict between ethnical groups in the aftermath of independence (Easterly and Levine: 1214). The continent has experienced several so called ethnical conflicts, with genocides like that in Rwanda being among the most chilling examples. The background for this conflict is of course far too complex to be blamed on ethnical cleavages alone, but it nevertheless proves how ethnic affiliation may come into play when societies are on the edge. Although not on the same scale as the Rwandan genocide, interplaying with environmental factors, I believe ethnicity may increase conflict risk. Environmental change could aggravate ethnical cleavages (Homer Dixon 1991), which again may increase the likelihood of conflict. Furthermore, stress on local environmental conditions, either through slow or rapid onset natural changes, could increase the likelihood of intergroup encounters. As water wells dry out, for instance, and people have to go further away in order to get hold of water, the likelihood of having to share the resource with other groups increases. This argument follows the neo Malthusian perspective in that environmental degradation, interacting with population pressure, leads to the competition over scarce resources. My argument is further based on the expectation that it is easier to fight people belonging to a different group than yourself, and when the primary identity is linked to ethnic belonging rather than nationality, this may further increase the risk of intergroup violence within the boarders of a state. In a sense, then, ethnic diversity is here hypothesized to increase the sensitivity of an area to the negative social consequences of climate change.

As previously mentioned, vulnerability is a product of three interrelated factors: exposure, sensitivity and adaptive capacity (Kinnas 2009: 5). Kinnas defines exposure as the degree to which a human group or ecosystem comes into contact with particular stresses, sensitivity as the degree to which a system will respond to a given change in climate including beneficial and harmful effects, and adaptive capacity as ability or capacity of a system to modify or change its characteristics or behaviour so as to cope getter with existing or anticipated external stresses (ibid). Together, the three are crucial in understanding the effect climate change will have on societies. Again, had it been only about biophysical risk, several developed countries would be as vulnerable to the effects of climate change as many developing countries now are (Barnett 2003).

The first of the three then, exposure, refers mainly to the purely biophysical risk. This depends directly on the geographical and climatic factors, which naturally includes rainfall. So my main hypotheses regard the effect of exposure, the purely climatic conditions. Yet exposure is clearly not enough to explain if and how societies are affected by climate change.

Sensitivity relates to the degree to which human and biological systems are impacted by these conditions. This in turn, depends on numerous other elements like infrastructure, existing natural hazards and dependence on agriculture, to mention a few (Boko et al. 2007). The effects of a drought will be more devastating where the natural environment is already under pressure, and a flood will sooner have ramifications on a village built from more traditional materials and tools than a on a concrete jungle. Furthermore, I have argued that ethnicity can be seen in connection with sensitivity; in increasing the sensitivity to conflict as a result of climate and environmental change.

Finally, adaptive capacity denotes the ability - and will - of a society to adapt to the damaging effects of climate change. This can be the diversification of agricultural products or the migration or mass movement of people in incidences of rapid onset disasters like floods (Boko et al. 2007: 454). Barnett (2003) connects the likelihood and intensity of conflict to time available for adaptive capacity. Logic suggests that the longer it takes for a society to adapt to the consequences and come up with solutions to relief its citizens of the economic and social burdens of climate change, the higher the risk of conflict.

These three overlap, mutually enforce one another, and are sometimes difficult to distinguish. Because vulnerability is such a complex phenomenon, it can be hard to measure and quantify (Adger 2006), yet as I will return to; I will use the two latter concepts as guidelines to my analysis when I determine the effect climate change has on violent conflict.

H3: the strength of the effect of rainfall variability on conflict depends on level of vulnerability

To summarize then, three hypotheses will be statistically analysed in order to study the relationship between climate change, understood as variations in rainfall, and conflict in Africa. These are founded in arguments based on the empirical literature, as well as on the theoretical background presented in this chapter. The first hypothesis is based on the expectation that both high and low levels of rainfall may influence conflict risk. While previous studies tend to focus mainly on the latter, I argue that excess in rainfall and rapid onset environmental changes too should be accounted for when studying this link. The second hypothesis states that this relationship should be more noticeable on conflict intensity than conflict onset, due to the expected relatively lower threshold for a conflict to intensify than for a conflict to break out. And finally, the third hypothesis presumes that these effects will be influenced by level of vulnerability. The latter term is understood to also include ethnic diversity, as this is expected to increase sensitivity to conflict, and be influenced by climate change as well. Before statistically analysing these hypotheses in chapter 5, a thorough description of how this is to be done will be given.

4 Research design and data

> *" Good, scientific research can be qualitative or quantitative in style, but in design it has four characteristics in common; the goal is inference, the procedures are public, the conclusions are uncertain and the content is the method"* (King et al. 1994: 8)

In order to study the theoretical assumptions motivating this thesis, a solid research design is needed. A research design is a detailed plan of how the research question is answered, and how the empirical analysis is structured (Skog 2004: 69). Here, statistical methods will be applied to answer the research question. This entails the expectation that the theoretical concepts that have been outlined are measurable, and is likely to have implications for my findings; as mentioned methodological choices seems to be crucial in understanding why different studies end up with different findings. Aiming to ensure the characteristics referred to by King et al. (1994), this chapter will provide a detailed overview of the how's and whys regarding methodological choices in this thesis.

To statistically study the relationship between rainfall and armed conflict, I have constructed a dataset of 43 African countries south of Sahara covering the year's 1981-2002, using data stemming from Buhaug (2010), Burke et al. (2009), the Social Polity dataset from the Quality of Government institute at the University of Gothenburg (Samanni et al. 2010), and the Emergency events database (EM-Dat) by the Centre for Research on the Epidemiology of Disasters (CRED) (2010). This provides a dataset with 890 observations in the main analysis. There are several steps to my analysis, and two different regression methods will be used; one for conflict onset and one for conflict intensity.

The research question that drives this thesis is whether extreme changes in rainfall, affects violent conflict. Both a major positive change and a major negative change in precipitation are expected to increase the probability of conflict. The effects are expected to be larger on conflict intensity than onset, and larger when interplaying with variables of vulnerability. It is furthermore expected that a different pattern might be found in East Africa than the rest of the continent due to the different climatological patterns of this region. Therefore I will run a selection of east African countries in a separate analysis, to compare the results to those of Sub Saharan Africa as a whole. If there is indeed a correlation between higher rainfall levels and conflict, this pattern might be more prominent in East Africa than Africa in general, although the limited number of units may prevent statistically significant conclusive evidence.

4.1 Defining East Africa

Due to the aforementioned distinct rainfall patterns of this region, East Africa provides a good “laboratory” to study the potential effects of excessive rainfall on conflict. Therefore, East Africa will be studied separately, in addition to being included in the main dataset.

The eastern parts of Africa go under many names, and there are various ways in which these definitions are being used. In some contexts, the region *East Africa* may consist of only a few countries. The East African Community (EAC) for instance, consists of five eastern African countries, and is commonly referred to when defining east Africa as a region (EAC 2010). The definition used by the UN on the other hand, is much more extensive, and includes no less than 19 countries (UN stat 2010). In addition, it seems that many of the studies on the topics of climate change, security and conflict use a variety of different definitions. I chose to follow a definition used by Schreck and Semazzi (2004). What they term eastern Africa, or Greater horn of Africa, consists of Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Uganda, and Tanzania (Schreck and Semazzi 2004: 681).

The reason I rely on this definition is my very reason for focusing on East Africa rests on the distinct nature of climate patterns that the study of Schreck and Semazzi (2004) has identified in just this region. Because of a large amount of missing values on key variables, Eritrea is left out of the analysis, and I am hence left with 9 east African countries.

4.2 Unit of analysis

The unit of analysis to be investigated here is country years; one particular country in one particular year. Although this is commonly used (Buhaug and Theisen 2010; Burke et al. 2009; Hauge and Ellingsen 1998; Miguel et al. 2004), it is not the only way to go about. Despite of its apparent popularity, the approach has its limitations. Both the geographical aspect and the time aspect could be more refined. Variations within a country can be great, both when it comes to weather events, social composition and conflict. Varied landscape creates different types of climates; Tanzania for instance has a large range of different climates due to the varied landscape encompassing everything from high mountains, long desert – like stretches of land, and endless savannahs to tropical forests, large lakes and a humid coastline. Resource availability may similarly vary significantly within the boarders of one state (Buhaug and Theisen 2010: 17), as a result of both structural and natural factors. In addition, partly due to the previously mentioned artificial nature of African boarders, demographic variations, also within the borders of a state, are large. Unlike in many other states, African borders do not follow ethnical and national identities, nor do identities necessarily follow the borders. This means that many African states are made up of several sub groups and societies that may have more in common with similar subgroups in neighbouring states than with their respective nationals. Climatic factors in one part of the country does not necessarily have anything to do with intergroup violence occurring in an other part of the country, and having country year as a unit of analysis does not capture these nuances. As seen, some studies have had a spatial disaggregation (Raleigh and Urdal 2007, Theisen et al. 2010) that may better capture some of these aspects. Yet while this spatial aggregation is more sensitive to geographical and demographical features like those just mentioned, there are reasons why state borders is a natural delimitation.

Hendrix and Salehyan (2010) argue that there is little reason to expect that the effects of local environmental conditions will be limited to the immediate area only. Acute resource shortage and failed agriculture in rural areas, for instance, will also be noticed on food prices in urban areas within the same state. So called eco migration is also much more likely to happen within the boarders of a state, and it is possible to imagine that many of those forced to leave their homes and villages may move into the urban centres. In this sense, more fine-tuned composition of grid-cell of a certain size, does not capture these political and economical conditions that are characteristic of a state. A political unit, however "artificially made" it is, and however elite driven, weak or centralized the power of this unit, still seems a logical choice for analysis.

Another valid approach, used by many scholars, would have been to use conflict years, hence have the years with conflict as the main observation rather than countries. The reason why this has not be chosen is that country years gives a better opportunity of comparing conflict events to non conflict events. While it is not rarely used, for the purposes of this thesis, it would entail an unfortunate selecting on the dependent variable. Furthermore, as I will be studying conflict *onset* in addition to intensity, using conflict years as unit of analysis would be difficult.

The decision to use country years provide me with 889 observations in the main dataset, and a total of 186 observations for the selection of east African countries.

4.3 Statistical methods

Two different regression methods will be used here due to the different characteristics of the dependent variables. Conflict onset is a dichotomous variable with the values 0 for no conflict onset, and 1 for conflict onset. Therefore, logistic regression is the best choice to analyse this model. Besides the difference in method however, the same variables will be applied in the analyses for both onset and intensity, again to maintain a basis for comparison.

The logistic regression model is based on a binary dependent variable. There are two versions of logistic regression outcome; log odds and odds ratio. Odds ratio, the odds for one group divided by the odds for another group, measures the relative change in the odds of having the value 1 in the dependent variable when there is a one unit increase in an explanatory variable, controlled for all other variables (Skog 2007: 364-

365). When odds ratio is 1, this describes a situation where the odds for both groups is equal. Log odds are the natural logarithm of odds, and are a bit more difficult to interpret. Where odds ratio have the value 1 indicating that two outcomes are equally probable, log odds have the value 0 (Hegre 2008). Log odds hence have both positive and negative values, where odds ratio only have positive ones (OR<1 indicates a negative correlation). The outcomes in tell how much the log odds change for a one unit increase in the independent variable.

The logistic regression equation can in its simplest form be written as

$$\tilde{Y} = \frac{1}{1 + e{-}(b_0 + b_1 \cdot x)^e}$$

In order to analyse the second dependent variable, intensity, ordered ranged logistic regression is applied. This is because, as I will return to, conflict intensity will be measured as a categorical variable. Ordered logistic regression is based the same logic as regular logistic regression, with the difference being that the “ologit” is designed for ordinal outcomes with more than two categories (Hamilton 2009: 279). It could in theory have been possible to use a linear model, but this would require a higher amount of categories in able to fulfil the requirements of a linear model. The advantage the ordered logistic model has over a linear one is that when the distances between the thresholds are unequal, a linear model where the ordinal variables are treated as interval can give misleading results, while the same is not true for the ordered logistic one (Armstrong and Jackson 2009).

In the latter approach, the coefficients tells us something about the increase in odds of being in a higher group on the dependent variable, for a one unit increase in the independent one – holding other factors constant.

4.4 Operationalization of variables

To be able to move from the theoretical discussion of phenomena to studying these empirically, it is crucial to define these phenomena in a way that can be measured (Hellevik 2002: 50 – 51). This is what is called the operationalization of the variables, and is an important part of the statistical analysis. Operationalizing refers to the process of making the theoretical concepts *quantifiable*; more specifically it means to make the concepts measurable through the development of indicators (Adcock & Collier 2001: 530-531). These indicators should be created in a careful manner to ensure that they do in fact measure the theoretical concepts they are meant to measure. This is denoted by the validity of a study, to which I will return in a later section.

4.4.1 The dependent variables

Most studies on the environment – conflict connection focus on civil war and internal conflict. Only few, like Gartzke (2010), examine the link between climate change and interstate war. This study comes short in finding any support for the hypothesis that climate change causes or in any other way affects when and if nations fight. Gartzke argues that if we are to say that global warming makes the world more violent, this must be a statement that applies generally and not just in special cases. Yet if the criterion to make such a statement is that it is applicable to interstate conflicts in general, it would be almost impossible to draw the conclusion that climate change makes the world less stable and more violent. Lack of interstate war does not automatically leave a peaceful world. Conflicts may also cross boarders without being classified as interstate; it is a well known fact that unease tends to spread. Furthermore, it should be recalled that state security is not only concerned with external threats, but also internal ones; meaning that interstate war is not the only choice when we want to make inferences about state security as well as individual security. Africa has since the end of colonization had remarkably few intestate wars (Henderson 2008:31), yet the continent has by no means been free of violence. Africa was a target of proxy wars during the cold war, and in the 1990s the continent saw several gruesome civil wars, like those in Rwanda, Sierra Leone and Liberia. In fact, in the 1980s and 1990s, 29 of the 43 countries in sub-Saharan Africa experienced civil conflict (Miguel et al. 2004: 726). Conflict here is hence defined in terms of internal conflict.

There are two dependent variables to be included in the statistical analyses. In the first analysis, the dependent variable is conflict onset. According to Ross (2004: 347) recent studies of conflict have relied on four datasets: Collier and Hoeffler (2002), Fearon and Laitin (2003), Elbadawi and Sambanis (2002), and Gleditsch et al. (2002), also known as the PRIO/Uppsala dataset. There are thus several different available sources of a conflict measure, and it is the definitions of these that are essential to my decision. Unlike the traditional definition of civil war used in several studies, with a conflict being defined by a minimum threshold of 1000 deaths, the data I will rely on here, Gleditsch et al. (2002), has a threshold of 25 battle related deaths. The theoretical arguments driving the search for a potential link between climate change and conflict are not applicable mainly to major civil wars. On the contrary, many of the assumptions regarding this link assume conflict in this context to be of relatively low intensity (Hendrix and Salehyan 2010; Meier et al. 2007).

The PRIO/Uppsala definition of conflict is as follows:

> "*... a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths*" (Gleditsch et al. 2002).

This implies that all conflicts that do not include involvement from the government of a country are excluded from this analysis. There are good theoretical reasons to include so called non-conventional conflict as well to draw inferences on the effects of climate change on conflict and security, especially because the threshold for violence may be lower when the government is not directly involved, and these forms of smaller scale conflict do not need government involvement (Hendrix and Salehyan 2010). Several of the studies I have mentioned here use civil war as a dependent variable. Others use violent conflict, and yet others argue that nonviolent conflict is more likely to be affected by climate change related factors. Hendrix and Salehyan

(2010) look at other forms of disorder than violent conflict, and argue that these are the forms of conflict that are most likely to be affected by rainfall variability since they do not require mass mobilization or resources. Yet their findings do in fact find the strongest correlation on violent events, indicating that even if at a lower level, rainfall variability might spark violence. Lower levels of conflict may also serve as a first step to violent conflict (Brown et al. 2007). While both types of conflict are interesting in this regard, for the interest of this thesis which aims to study conflict as an expression of (in)security in the more traditional meaning of the word, studying violent conflict is more fruitful. This is additionally based on the fact that my arguments to a large degree are based upon what other studies have done – and the majority of these studies look at a form of violent conflict. Furthermore, for violent conflict including a certain number of casualties, I argue that some sort of government involvement is likely in the majority of the cases.

Another characteristic about the abovementioned definition of conflict worth mentioning is that a conflict with 25 deaths in the period November – February may not be registered as a conflict, while the same amount of battle related deaths from January – December will. This is however not expected to have any large implications for this study, since this is the same for previous studies relying on the same definition.

The conflict onset variable is taken as found in Buhaug (2010)'s replication data. Since several of the replication datasets I have used contained a conflict variable based on the same criteria and derived from the same source, the Gleditsch et al. dataset, the decision on which one to use was based on amount of missing values. The differences between the measures were not that great however, and a correlation of the various measures revealed that besides the missing values, the variables were, as is to be expected, pretty much identical.

Conflict intensity is here being operationalized as number of deaths, although other aspects too could be included to measure intensity. I do however hold number of deaths to be an appropriate measure of conflict intensity, especially since the focus here is on violent conflicts, and the conflict onset variable is based on the same measure. As violence increases it is likely that the number of injured increases with a simultaneous and proportional rise in number of deaths. Hence I expect the injury – casualty ratio to stay more or less the same as the conflict grows or intensifies. Since conflict is defined and operationalized as armed conflict including a certain amount of casualties, it is natural that conflict intensity is defined as a increasing/decreasing function of this.

Ideally, this would have been measured as a linear variable with absolute numbers of casualties, much like how severity was measured in Hauge and Ellingsen´s study (1998). However, as this proved difficult given both a lack of data availability and certain aspects of my design, the intensity variable is constructed based on a division into three categories; value 0 refers to situations of "no conflict", or low intensity, as this is defined by Gleditsch et al. (2002), meaning from 0 to 24 deaths. Category one is that of medium intensity, including those cases where a conflict has between 25 and 999 casualties in a year. Finally, category two consists of those conflicts that in literature are often referred to as civil wars, conflicts with 1000 or more casualties.

A characteristic of this new variable worth mentioning is that category two is made from the onset variable of Buhaug (2010), and category three is from the civil war variable of Burke et al. (2009). While Buhaug have specified that "his" variable follows the so called two year rule, indicating that a conflict must have been dead for minimum two years to be coded as onset, no such specification is made in the variable derived from the Burke et al. data. Because the new variable is meant to measure intensity and not onset, this is not likely to cause any significant problems, but is important to be aware of.

4.4.2 The independent variables

The main explanatory factor of interest in this study is rainfall variability. Because I seek to look at intra annual variations in rainfall, I face some difficulties in the design. Due to my arguments regarding the characteristics of rainfall and that both amount and timing should be accounted for - the aim was to have an independent variable that captures both intra annual trends as well as variations in rain, in a good way. My preferred strategy would be to look at monthly change – and use months as units rather than years. A similar approach was implemented by Meier et al. (2007),in a study of environmental variability and pastoral conflict in east Africa. Based on my main arguments, this seemed a logical choice for the purposes of this thesis too. Despite my repeated attempts to get a hold of such data, however, none were found, and the decision was made to go with the second best strategy, using yearly data.

The independent variables are collected from two different sources. To properly measure all aspects of rainfall variations, I include climatic anomalies, drought and flood in the analysis. In a recent study, Buhaug (2010) introduced a rainfall variable that does much of what I have argued as important when studying the effects of rain. In his study, inter-annual growth, i.e. the proportional change since the previous year, *and* climate anomaly, i.e. proportional deviation from mean annual levels of precipitation, are both applied (ibid: 4). Measuring not only yearly change, but also deviation from annual mean, these indicators capture the complexity of rainfall variability more satisfactory than those of several other studies that measure inter – annual growth only. In addition to the original variables, these measures are recoded into variables with 4 categories reaching from little change to extreme change. This operation has two advantages; first of all it makes it possible to study the effects of only the size of the deviation, in addition to the original variable measuring direction. Secondly, it facilitates the interpretation of interaction terms. After trying to divide the categories in percentiles of 25 % and finding that such an approach gave a distribution too skewed to make sense, the lowest category now reaches from 0 to 15 percent, and the highest from 70 percent and up. While the distribution of observations in each category is still unequal, it provides a good middle way between the need to have equal categories and the need to have categories reflecting a theoretically defendable image of reality.

As a supplement to the rainfall indicators, being expressions of what Hendrix and Salehyan termed hydro-meteorological disasters (2010), measures of flood and drought are also included as explanatory variables. This data is collected from the

Emergency Events Database EM-DAT, developed by Centre for Research on the Epidemiology of Disasters (CRED), and give the total number of each one of these natural disasters for each country and year. For a disaster to qualify for inclusion in this database, at least one of four criteria's must be met: a minimum of 10 people reported dead, at least 100 people reported affected, a declaration of a state of emergency, or a call for international assistance (CRED 2010). What could be problematic in this regard, is that whether or not a disaster is reported is very much dependent on political will. The criteria are based on voluntary reporting disasters, and involving the international community, which may create a bias of underreported natural disasters some places, especially in countries with oppressing regime types. While it is important to beware of this, I do not see this as a big enough problem to exclude the measures from the analysis, especially since a look at the data reveals the distribution of reported events is fairly even. It may also be useful to keep in mind that value 0 does not necessarily mean that no disaster took place, it simply means that no disaster was reported.

A benefit of using flood *and* drought, is that they measure both rapid and slow onset changes, respectively. This makes it possible to measure the expectation that these may have different effects on the dependent variable, as argued in chapter 3. I hence expect flood to have a more immediate effect on conflict than drought. Furthermore, these indicators measure different sides of the rainfall scale, with flood being theoretically closely tied to my argument regarding too much rain**.** The variables thus partially make up for the lack of an intra – annual measure in the precipitation variable, through clearly measuring episodes related to too much or too little rain.

4.4.3 The control variables

As mentioned previously, analysing the effects of climate change alone is not satisfactory to study the consequences of climate change. Other factors may in themselves be causally linked to the dependent variable, as well as to the independent variables. These alternative explanations for the phenomenon being studied should be accounted for, and controlling for other factors eliminates competing explanations and give more strength to the model (Skog 2004:107). The control variables are chosen based on what is traditionally understood and proven as being linked to conflict, in addition to being based on the notion of vulnerability. The same indicators hence serve as control through being additional explanation variables, in addition to being included in interaction with the main independent variables.

4.4.3.1 Ethnicity

Theoretically there are numerous ways in which ethnicity and ethnic cleavages can relate to conflict. Buhaug (2010) for instance, applies a measure of ethnic group`s access to power; ethno political exclusion. In this thesis however, ethnicity will not only be used as a control variable included to account for alternative explanations of conflict, but is also assumed to interplay with the main independent variable and determine the effect this has on conflict. The focus here is on ethnic diversity, based on the aforementioned argument that environmental stress might increase the risk of intergroup encounters. This argument depends on number of ethnical groups. A higher number of ethnical groups might also indicate that the number of different communities, run as subunits within the country is higher. In places where distances are large and infrastructure limited, interaction between communities is not always widespread. As environmental stress limits the availability of resources however, this might change. Ethnical diversity will hence be operationalized as ethnic fractionalization, indicating number of ethnical groups.

Importantly, this variable may capture more than just ethnicity. Ethnicity in itself is often conceived as being a socially constructed component of our identity, and may as well relate to class and politics as to race and ethnic background (Fearon and Laitin 2000: 858). Hence if found to be statistically significant, this should be taken into consideration when concluding the effect. Yet while it is uncertain to what degree a measure of ethnicity measure other socio economic factors, it is certain that it does in fact measure ethnicity.

The variable is collected from the quality of government dataset (Samanni et al. 2010), but originates in that of Alesina et al. (2003), and measures degree of fractionalization on a scale from 0 to 1. Following my arguments, it is expected that as this indicator moves towards higher values, the risk of conflict increase. Empirically, the link between ethnic fractionalization and conflict is not proven, with some studies finding little evidence of such a link (Miguel et al. 2004; Fearon and Laitin 2003)[4]. Theoretically however, there are as argued well-founded reasons to expect ethnic diversity to have an impact on conflict, also in interaction with climate change.

4.4.3.2 Vulnerability

The theoretical concepts that will be controlled for here, based on the notion of vulnerability as discussed in chapter 3, leave a variety of choices when it comes to operationalization. Since vulnerability is not easily defined or quantified, the variables included are also partly based on what is traditionally seen as the most influential of conflict. As already emphasised, vulnerability is made up of three interrelated components. The first one, exposure, is already being tested for through rainfall variability, and no further variables related to this will be included.

When it comes to sensitivity and adaptive capacity, since the two are interrelated, several factors fit in both categories. First of all, level of development will dictate both the degree of sensitivity, understood as the degree to which a system is impacted by climatic change, and the ability of a society to adapt to this. It has been claimed that properly functioning economic institutions, and economic prosperity can provide incentives to encourage preservation and develop new sources of resources (Homer Dixon 1999: 25). In this thesis, GDP per capita is being used as an indicator of level of development. Economic factors not only determine how well a society adapts to and avoid the most acute harms of climate change, but are also often mentioned as alternative reason for conflict. Poverty is believed to be one of the main contributors to conflict today, this way GDP measures both vulnerability and provides an alternative

[4] Slettbak and DeSoysa (2010), however, find ethnic fractionalization to be significant and positively correlated with conflict.

explanation for conflict**.** The variable originates in the Buhaug (2010) dataset. It is log transformed to account for a right skewed distribution , and is also recoded into four equal categories and included in interaction terms with rainfall variability measures. Through the interaction term, the variable capture some of the expectations of neo Malthusian deprivation hypothesis as well (Kahl 2006).

Another crucial factor that is related both to vulnerability to climate change, level of development and conflict in general, is system of governance or state capacity. Again, this is assumed to be closely linked with both sensitivity and adaptive capacity, but perhaps especially the latter. It might also have an impact on the independent variables in that both the flood and drought indicators are dependent on reporting, and thus political will and ability to do so. State capacity or regime type is operationalized through the indicator *polity2*, measuring democratization on a scale from -10 to +10. This variable stems from Marshall and Jaggers polity IV dataset (2009) , as is found in the Burke et al. (2009) replication dataset.   Political protest and violence is least common in highly repressive authoritarian regimes, more common in democracies, and most common in hybrid regimes (Hendrix and Salehyan 2010: 16). One explanation for this is that authoritarian regimes tend to be more repressive, and will through force prevent people from turning to violence, especially violence directed against the state, which is the type of conflicts that will be in focus here. It is furthermore believed that democracies will be better at providing other outlets and alternatives to violence, so that the closer we get to a perfect democracy, the less conflict. This is related to the neo Malthusian state failure hypothesis, claiming that environmental scarcity related deprivation will only turn in to violence where the state is to weak to prevent it (Kahl 2006:10). Hence I expect a curvilinear shape where the effect of climate change on conflict is larger the closer we get to the middle. The notion of a curvilinear relationship between polity and conflict is well backed by previous empirical studies as well, showing that the middle values are in fact more prone to conflict (Slettbak and deSoysa 2010). Because I expect such a relationship, I introduce a *polity squared* variable, which accounts for curvlinearity. Additionally, this indicator too is included in interaction terms, both in its original form and as a recoded variable with 4 equal categories.

Finally, for statistical control, population size is also included in the analysis[5]. The battle death threshold of 25 is presumably easier met in Nigeria than in Djibouti given that Nigeria has roughly 150 to 200 times more people than Djibouti. Together with GDP, population size is one of the most common control variables included in the civil war literature (Hegre and Sambanis 2006: 512). This variable too is log transformed, and is taken from the Buhaug (2010) dataset.

All variables were correlated to ensure that the independence between them was satisfactory. The highest correlation was between ethnic fractionalization and log transformed GDP, with a value of about 0.4, and multi-collinearity does hence not represent a problem.

4.5 Reliability and validity

For all scientific research, there are certain methodological goals that should be aimed for in order to ensure the quality of the analysis. These are reliability and validity. Reliability refers to the way data is measured, and when achieved to satisfaction it entails the expectation that a study is replicable. This basically means that any other scholar with the desire to do so, should be able to follow your steps and easily replicate your study. In a statistical study, the reliability is closely connected to accuracy in the collecting of data (Hellevik 2002: 183).

The data being used here, in addition to stemming from respectable sources, has all been published in the past. The only variables not extracted from a pre-existing dataset, flood and drought, were downloaded in excel and changed by hand before transferred to the statistical package Stata. The changes made were purely cosmetical,

[5] Based on arguments about population pressure, and on the general concern that migration is liked to conflict, a measure of hosted refugees stemming from Gleditsch and Salehyan (2006) was also included in the analyses. Because this variable had a large amount of missing, however, and its inclusion did not change the general picture, the variable was omitted and is not demonstrated in the models in this thesis.

yet the data was thoroughly checked and double checked before included in the main dataset, to ensure that no unintended changes had occurred. Other than that, few changes have been made to the data, and those that have been made are well accounted for. Hence the reliability of the data is considered to be high. This also goes for the reliability of the study as a whole, as every step is accounted for and documented in the *do file.*

High reliability is furthermore a necessary condition for high validity (Hellevik 2002: 52). Validity has to do with data relevance and how well the theoretical concept is captured and defined in the operationalized indicator. Together with reliability, this definitional validity make up the validity of the data (ibid: 52; 183).

It is relatively safe to say that the first dependent variable, conflict onset, is a relevant measure of conflict onset, and fulfils the requirements of what is called face validity (ibid: 52). This can also be said for the independent variables. Measuring rainfall, flood and drought, they capture both the slow and rapid nature of rainfall, as well as rainfall relative to the normal. The issue of conflict intensity is a bit more problematic however. As mentioned, with only three categories, this is far from a perfect indicator of conflict intensity understood as number of battle related deaths. A measure in absolute numbers would have been preferred. What is more, it can be argued that a conflict's intensity is much more than casualties. Yet because this is the measure of intensity given in most of the conflict literature, and based on the aforementioned logic of violence and battle related deaths, I argue that battle related deaths is a valid measure of conflict intensity. While the categorical variable does measure intensity, it is however a somewhat limited measure of this.

The vulnerability measures may also say to fulfil the requirements of validity. While vulnerability entails a lot more than what is being measured here, it would be impossible to include them all, and the indicators included are in fact theoretically closely linked to vulnerability as defined in the literature (see Kinnas 2005).

5 Findings and analysis

The hypotheses presented in this thesis presume that there is a positive relationship between rainfall extremes and conflict, that this relationship is stronger for conflict intensity than onset, and that the effects are stronger the higher the level of vulnerability. It is further expected that for especially the first hypothesis, the effects of *positive* rainfall extremes on conflict should be more noticeable in East Africa. In this chapter I present the results and findings of the regression analyses, and then explore whether and to what extent my hypotheses are supported by statistical evidence**.** Does *this* analysis give a clearer picture of a potential link between rainfall variability and violent conflict?

In the analyses of rainfall variability, both the original variables, and a set of recoded variables were tested[6]. The reasoning behind the recoding was originally embedded partially in the wish to simplify the making and interpretation of indexes and interaction terms, ensuring that the variables were on the same scale. These recoded variables then say nothing about whether the precipitation increases or decreases, just about *how much* it changes, which is in line with the arguments that an increase in rainfall should be accounted for at the same level as decrease. Flood and drought are included as indicators of hydro-meteorological disasters, measuring rapid and slow onset changes, respectively.

To test the hypothesis that level of vulnerability will influence the strength of the effect rainfall variability might have on conflict, vulnerability variables are included both as normal control variables standing alone, and in interaction with the main precipitation variable.

[6] Naturally, not all run test will be presented in this section, however, the models presented are mainly representative of the general findings.

The main analysis covers 41 countries in sub Saharan Africa, in the years 1981 to 2002. For one observation in every country and year, this makes a total of 889 observations.

This analysis differ from earlier studies in two main respects; first of all I include measures for flood and drought and test these along with the precipitation measures both on Sub Saharan Africa, and on a selection of east African countries. This is founded in the expectation that we might see a slightly different pattern in East Africa with regards to, especially excessive, rainfall. And second, I run the same tests on conflict *intensity,* as on conflict onset, based on the argument that the nature of ongoing conflicts may be more affected than the initiation of new ones.

5.1 Conflict onset – logistic regression analysis

In the pursuit to find out weather the analyses can provide support for the hypotheses posed in this thesis, several models were tested. The models selected to be presented here are representative of the general pattern found throughout all the analyses performed. In the models termed "A", the original variables have been used, while letter "B" indicates that the analysis has been performed with the recoded variables consisting of four categories. Furthermore, the first model, 1.0A, the main independent variable is precipitation *change* compared to previous year, while in the rest of the models the precipitation variable indicates *deviation* from long term trend. For reasons of simplicity and comparison, these patterns are followed for all the tables.

The coefficients are reported in *log odds*.

5.1.1 Sub Saharan Africa

A quick look at table 1 reveals first of all that few of the variables turn out statistically significant.

Table 1: Results for conflict onset in Sub Saharan Africa

	Model 1,0A	Model 1,1A	Model 1,2A	Model 1,2B	Model 1,1B
explanatory variables					
precipitation	-0.164	0.168			0.166
	(0.582)	(0.714)			(0.282)
precipitation 1lag	-0.216	-0.771	-0.729	-0.516	-0.543*
	(0.636)	(0.862)	(0.871)	(0.328)	(0.328)
precipitation 2lag	0.576**	1.531**	1.542**	0.464*	0.455*
	(0.237)	(0.727)	(0.730)	(0.273)	(0.273)
flood	0.115	0.113	0.121	0.118	0.117
	(0.221)	(0.222)	(0.221)	(0.213)	(0.213)
drought	-0.205	-0.202	-0.206	-0.199	-0.211
	(0.497)	(0.497)	(0.497)	(0.498)	(0.498)
interaction					
interaction			0.003	0.031	
			(0.098)	(0.113)	
other variables					
Log GDP	-0.205	-0.178	-0.171	-0.090	-0.045
	(0.284)	(0.281)	(0.280)	(0.334)	(0.271)
Ethnic Fract.	-0.048	0.092	0.104	0.060	0.060
	(1.002)	(0.983)	(0.985)	(0.226)	(0.227)
squared polity2	-0.024**	-0.023**	-0.023**	-0.783**	-0.785**
	(0.007)	(0.007)	(0.007)	(0.249)	(0.249)
log population	-0.030	-0.073	-0.076	-0.082	-0.074
	(0.155)	(0.149)	(0.149)	(0.152)	(0.152)
Constant	-0.444	-0.322	-0.361	-0.900	-1.156
	(2.669)	(2.681)	(2.673)	(1.990)	(2.038)
statistical measures					
Observations	832	832	832	832	832
Log likelihood	-160,557	-161,954	-161,979	-162,816	-162,683
Pseudo R2	0.0674	0.0593	0.0591	0.0543	0.0550

Standard errors in parentheses
** p<0.05, * p<0.1
Letter A indicating model with original variables, B indicating model with recoded variables

Model 1.0 is run with precipitation *change* as dependent variable, the rest with precipitation *deviation*

Of the explanatory variables, precipitation only turn out significant when lagged two years, with positive values in all the models. The effect is weaker for *change*, shown in the first model, than for *deviation*, but the effects seem fairly robust and give the same significant values in all models. This is also the case for several of the models not demonstrated here, including when only the explanatory variables are included in the model. For the original precipitation variable this substantially means that a *growth* in rainfall is associated with conflict two years down the line, while for the recoded ones in models B, it means that *deviations,* both positive and negative, are positively correlated with conflict two years after. For the original variables, the values stay consistently at 1.5, while the recoded measure has a value of 0.45. Furthermore, in the last model, precipitation lagged one year also turns out significant, but with negative values. This pattern is consistent, although mostly not statistically significant, throughout the models. The two measures of hydro meteorological disasters also point in opposite directions, with flood always giving positive values, and drought giving negative ones. None of these measures turned out significant in any of the models however, but do nevertheless stay remarkably consistent.

The only interaction term presented in the table is that including precipitation and GDP, both for the original and for the recoded variables. Precipitation was omitted in these tables, because the multiplicative terms are meant to capture the effect precipitation has in interaction with vulnerability variables[7]. However, comparing this to the models without such interaction terms, it is clear that the inclusion of these terms has very little effect[8]. This was also the case for the interaction terms constructed of precipitation, and ethnic fractionalization and polity respectively.

A bit surprisingly perhaps, the only statistically significant control variable is squared polity. This measure stays significant at a $p<0.05$ level throughout the analysis, with small negative values of 0.023 for the original variables, and 0.78 for the recoded ones indicating that a shift towards democracy slightly decreases the risk of conflict onset.

Since the control variables in this analysis are commonly used by the general literature, being theoretically closely linked to conflict, it is also surprising that

[7] When the original precipitation variable is included in a model with interaction, the values for both precipitation and the interaction term become extremely high, as do the standard errors.

[8] To account for the fact that GDP and precipitation are theoretically assumed to have opposite effects on conflict risk, interaction terms were also included where GDP was reversed. This made no difference.

pseudo R2[9] values are so low. Although this measure should be interpreted with caution, it is evident that the values of this measure are in fact very low. These values roughly indicate that only 5-6 per cent of the variance is being explained by the independent variables in these models.

To get a closer look at a potential correlation between the independent variables and conflict onset, regression analyses were also performed testing only the cases where precipitation values are positive, indicating an increase in rainfall compared to the average. The same was done for only negative values, and for the cases where the recoded deviation measure had values of 2 or more, indicating large deviations from average rainfall. The general patterns turned out quite similar to that in table 1. Additionally, both flood and drought were lagged to test for potential delayed effects of these on conflict. Theoretically, especially in the case of slow onset disaster *drought*, this should give some results. None of these indicators however, showed any sign of being significant when lagged, although drought did perform slightly better when lagged one year, corresponding with the expectations that slow onset changes may also take more time in influencing conflict.

To see if these general findings changes where precipitation patterns are different, 9 east African countries were isolated and studied apart[10].

5.1.2 East Africa

As mentioned, to avoid complicating the potential for comparing the models in the different tables, the same models are demonstrated and presented for the selection of east African countries as for the main data.

[9] The Pseudo R2 measure reported here is that of McFadden. Substantially it has less meaning than the r squared measures in linear regression, yet it nevertheless says something about how much of the variance in the dependent variable is explained by the variables in the model.

[10] The same data including all countries expect for the east African ones was also studied. The main findings using this approach was very similar to those demonstrated in table 1.

Table 2: Results for conflict onset in East Africa

	Model 2,0A	Model 2,1A	Model 2,2A	Model 2,2B	Model 2,1B
explanatory variables					
precipitation	-0.182	0.105			-0.505
	(1.199)	(1.059)			(0.580)
precipitation 1lag	0.368	-0.299	-0.202	-0.201	-0.273
	(0.482)	(1.133)	(1.161)	(0.533)	(0.543)
precipitation 2lag	0.930**	1.365	1.363	1.130**	1.152**
	(0.453)	(0.982)	(0.986)	(0.512)	(0.504)
flood	0.388	0.443*	0.455*	0.343	0.344
	(0.279)	(0.269)	(0.269)	(0.277)	(0.273)
drought	-0.006	0.009	0.001	-0.062	-0.081
	(0.743)	(0.739)	(0.741)	(0.795)	(0.787)
interaction					
interaction GDP			-0.020	-0.303	
			(0.151)	(0.227)	
other variables					
Log GDP	-0.012	0.253	0.272	2.513	1.439
	(1.026)	(0.990)	(0.997)	(1.747)	(1.307)
Ethnic fract.	-2.159	-1.294	-1.261	-0.567	-0.522
	(1.758)	(1.514)	(1.505)	(0.449)	(0.438)
squared Polity2	-0.013	-0.009	-0.009	-0.405	-0.310
	(0.014)	(0.014)	(0.014)	(0.528)	(0.513)
log population	0.450	0.138	0.126	0.442	0.391
	(0.472)	(0.388)	(0.384)	(0.405)	(0.396)
Constant	-5.359	-4.767	-4.801	-10.308*	-8.012
	(9.321)	(9.178)	(9.215)	(6.141)	(5.633)
Statistical measures					
Observations	186	186	186	186	186
Log likelihood	-53,146	-45,869	-45,865	-43,239	-43,793
Pseudo R2	0.1314	0.0766	0.0767	0.1295	0.1184

Standard errors in parentheses
** p<0.05, * p<0.1
Letter A indicating model with original variables, B indicating model with recoded variables
Model 2.0 is run with precipitation *change* as dependent variable, the rest with precipitation *deviation*

In general, there is not much change from the main data. When lagged two years, precipitation give a bit higher values in the models with recoded variables, and stay significant in these. In the models with original variables however, it loses significance. What is perhaps interesting, is that in these models *flood* turn out significant at a $p<0.1$ level, with values being slightly higher than when studying sub Saharan Africa. These values stay consistent throughout the performed tests, being statistically significant in the majority of the models for east Africa, both when standing alone and when all other variables are included. When it tends to lose significance however, is when the recoded variables are included and the hydro - meteorological measures are not lagged.

In these tests, none of the control variables, nor the interaction terms turn out significant. The overall explained variance is slightly higher than those in table 1.

Conflict onset summary[11]

The main pattern when studying precipitation variability and conflict onset then, is that of few statistically significant outcomes, relatively consistent patterns, and low explained variance.

While the latter is based on a measure that is difficult to interpret, the Pseudo R2 also indicates that precipitation performs slightly better when measuring change from previous year than when measuring deviation for average means, as seen in the difference between the otherwise equal models for precipitation change and precipitation deviation. This is contrary to the expected outcome. Since these differences are relatively small, and are furthermore not consistent throughout the models, the focus remains on precipitation *deviation* as this is closer to my theoretical arguments.

5.2 Conflict intensity

To explore the relationship between rainfall variability and categorical dependent variable conflict intensity, ordered logistic regression analysis was used. The

[11] In addition to conflict onset, some tests were also performed using conflict incidence as the dependent variable, holding conflict onset at 0. This revealed a slightly different pattern; with positive and significant values for drought and population size and negative significant values for both GDP and polity. None of the precipitation measures were significant using this approach.

interpretation of the coefficients in the ordered logistic model is based on the same logic as in regular logistic regression. The coefficients express the log odds of being in a higher conflict group for a one unit increase in the independent variable, all other factors held constant (Hegre 2008). Furthermore, statistical package *Stata* reports two constants. These represent the cut points between the three categories; the first constant denotes the log odds of being in a group higher than the lowest group vis a vis *in* the lowest group, all other factors held constant, and the second denotes the log odds of being in a higher than the second group vis a vis equal to or smaller than the second group, all other factors held constant.

5.2.1 Sub Saharan Africa

As with the analyses for conflict onset, all models were first tested on Sub Saharan Africa as a whole.

From the table demonstrating the results for the ordered logistic regression analysis of the categorical intensity variable, it immediately becomes clear that the explanatory variables do not perform better here than in the logistic analyses. Only in one of the models do any of the explanatory variables turn out statistically significant; when lagged two years, precipitation *change* is positive and significant at the 0.05 level. Yet the patterns in regards to direction of the coefficients is very much the same as that in tables 1 and 2. Of the control variables, in addition to polity, log population is positive and significant in all models. Substantially, this means that higher population size increases the risk of being in a higher conflict group. As these groups measure total amounts of battle deaths, it is not surprising that higher total population is associated with higher total number of battle deaths.

What also changes from the analyses of onset is that when drought is lagged, both one and two years, it turns out positive and significant at the 0.05 level. Furthermore, as can be seen in table 3, when using intensity as the dependent variable, flood and drought follow a pattern quite opposite of that seen in the first two tables.

Unlike in the logistic regression analyses for conflict onset, the constants appear significant in some of the analyses of conflict intensity. What they demonstrate, in models 3.2B and 3.1B, is that the log odds of being in a higher conflict group, all other factors held constant, is the same for both cut points.

Table 3: results for conflict intensity in Sub Saharan Africa

	Model 3.0A	Model 3,1A	Model 3,2A	Model 3,2B	Model 3,1B
explanatory variables					
precipitation	-0.182	-0.006			0.167
	(0.475)	(0.633)			(0.192)
precipitation lag1	-0.187	-0.346	-0.340	-0.066	-0.087
	(0.471)	(0.638)	(0.641)	(0.201)	(0.201)
precipitation lag2	0.404**	0.912	0.914	0.234	0.224
	(0.170)	(0.563)	(0.564)	(0.193)	(0.193)
flood	-0.181	-0.185	-0.184	-0.194	-0.196
	(0.154)	(0.155)	(0.154)	(0.151)	(0.151)
drought	0.285	0.281	0.280	0.320	0.312
	(0.278)	(0.278)	(0.279)	(0.278)	(0.278)
Interaction					
interaction			-0.003	0.032	
			(0.086)	(0.083)	
Other variables					
log GDP	-0.318*	-0.294	-0.294	-0.327	-0.281
	(0.183)	(0.181)	(0.181)	(0.227)	(0.185)
ethnic fract	-0.323	-0.213	-0.213	-0.016	-0.016
	(0.664)	(0.655)	(0.655)	(0.152)	(0.153)
squared polity2	-0.009**	-0.009**	-0.009**	-0.363**	-0.363**
	(0.004)	(0.004)	(0.004)	(0.135)	(0.135)
log population	0.407**	0.376**	0.376**	0.387**	0.395**
	(0.104)	(0.101)	(0.101)	(0.102)	(0.103)
cut 1, constant	2.712	2.639	2.640	4.189**	4.458**
	(1.726)	(1.729)	(1.727)	(1.281)	(1.324)
cut 2, constant	3.163*	3.088*	3.089*	4.639**	4.909**
	(1.727)	(1.730)	(1.729)	(1.283)	(1.326)
statistical control					
Observations	825	825	825	825	825
Log Likelihood	-388,434	-389,93	-389,929	-288,393	-388,1
PseudoR2	0.0471	0.0434	0.0434	0.0472	0.0479

Standard errors in parentheses
** p<0.05, * p<0.1
Letter A indicating model with original variables, B indicating model with recoded variables
Model 3.0 is run with precipitation *change* as dependent variable, the rest with precipitation *deviation*

Also, the Pseudo R2 measure is in general slightly lower than in the first two tables, informing that the independent variables used in the statistical analyses do not seem to explain more of the variance in conflict intensity than conflict onset, as I assumed in the second hypothesis.

5.2.2 East Africa

Finally, the same analyses of conflict intensity was performed on the east African countries.

In these models, the only statistically significant variable is log population. Since the number of observations is as small as it is, it is perhaps not to be expected that a categorical dependent variable would give significant results**.**

In regards to the general patterns compared to conflict onset for east Africa, two small changes appears; both flood and polity have changed sign. None of the two however are statistically significant, and the log odds value for polity of 0.006 is dangerously close to zero.

Compared to the main table for conflict intensity, the pattern is very similar here as well. Drought is the only variable pointing in the opposite direction from what it did in the main table, which is consistent with what was seen in the tables for conflict onset. Unlike what was found when comparing the two *onset* tables, however, the overall explained variance for conflict intensity is more or less the same regardless of whether it is the main data or the dataset for East Africa that is being analysed.

Table 4: Results for conflict intensity in East Africa

	Model 4,0A	Model 4,1A	Model 4,2A	Model 4,2B	Model 4,1B
explanatory variables					
precipitation	-1.027	-0.972			-0.276
	(0.783)	(0.913)			(0.336)
precipitation lag1	-0.135	0.284	0.286	-0.252	-0.281
	(0.397)	(0.735)	(0.742)	(0.315)	(0.316)
precipitation lag2	0.256	0.351	0.362	0.259	0.282
	(0.200)	(0.662)	(0.667)	(0.310)	(0.308)
flood	-0.059	-0.051	-0.057	-0.119	-0.130
	(0.191)	(0.190)	(0.190)	(0.191)	(0.191)
drought	-0.306	-0.244	-0.246	-0.185	-0.203
	(0.445)	(0.447)	(0.447)	(0.449)	(0.447)
Interaction					
interaction			-0.123	-0.170	
			(0.124)	(0.149)	
Other variables					
log GDP	-0.156	-0.128	-0.120	0.894	0.497
	(0.552)	(0.547)	(0.547)	(0.989)	(0.858)
ethnic fract.	-0.250	-0.157	-0.168	-0.141	-0.145
	(0.881)	(0.846)	(0.846)	(0.238)	(0.237)
squared polity2	0.006	0.006	0.006	0.221	0.236
	(0.008)	(0.008)	(0.008)	(0.335)	(0.332)
log population	0.419*	0.373*	0.377*	0.458*	0.471**
	(0.241)	(0.222)	(0.222)	(0.243)	(0.240)
cut 1, constant	3.699	3.539	3.612	6.382*	5.803*
	(5.150)	(5.132)	(5.130)	(3.594)	(3.514)
cut 2, constant	4.098	3.935	4.007	6.783*	6.203*
	(5.153)	(5.135)	(5.132)	(3.599)	(3.519)
statistical control					
Observations	185	185	185	185	185
Log likelihood	-132,941	-134,387	-134,451	-133,056	-133,397
PseudoR2	0.0445	0.0341	0.0336	0.0436	0.0412

Standard errors in parentheses

** p<0.05, * p<0.1
Letter A indicating model with original variables, B indicating model with recoded variables
Model 4.0 is run with precipitation *change* as dependent variable, the rest with precipitation *deviation*

Intensity summary

The two tables demonstrating the relationship between rainfall variability and conflict intensity, do not reveal any significant links between these two variables. The only explanatory variable to turn out statistically significant in the analysis of conflict onset, has now lost its significance. Additionally, the measures for hydro meteorological disasters have changed sign in table 3, now indicating that flood is negatively correlated with conflict while drought is positively correlated.

5.3 Analysis summary

The statistical analyses in this thesis have been performed with basis in thee theoretically founded hypotheses regarding the relationship between rainfall variability and violent conflict. The first hypothesis was mainly motivated by the expectation that both negative and positive rainfall variations should be accounted for;

H1: extreme variations in rainfall are positively correlated with conflict.

This would entail that the precipitation indicators give positive and robust values. It remains clear from the models presented here that they do not. When lagged two years, the indicators for both change from previous year and deviation from average amounts do stay positive and significant throughout the models for conflict onset, but this pattern remains a bit difficult to explain due to the fact that the opposite pattern is found when the variable is lagged one year. There was no large difference between the coefficients in the models for only negative precipitation values and the ones for only positive values. Hence this analysis can not support the hypothesis that heavy rainfall or decreased rainfall have any influence on conflict onset, nor on conflict incidence. To account for what has been referred to as hydro meteorological disasters (Hendrix and Salehyan 2010), measuring both slow and rapid onset changes related to rainfall, indicators for flood and drought were included in the models. This partially accounts for the fact that intra annual rainfall variability was not as well covered by the data as I had initially hoped. While it is interesting that these measures point in opposite directions, they nevertheless do not turn out consistently significant, and hence do not lend much support to the first hypothesis either. The fact that flood shows signs of having an influence on conflict in east Africa, and that precipitation lagged two years is positive and significant in all the logistic regression analyses, is not enough to conclude with support for the hypotheses that rainfall variability is particularly influential on conflict. Furthermore, the fact that none of these indicators were significant in the ordered logistic analyses either, clearly strengthens this conclusion.

The second hypothesis;

H2: Rainfall variability has more impact on conflict intensity than on conflict onset,

was tested through applying a categorical conflict variable with three categories. It was expected that this would reveal a higher correlation between the explanatory variables and the dependent variable than when using conflict onset, but no such pattern was found. If anything, it may even seem that the contrary of my hypothesis is true, the rainfall variables seem to matter even less in these models; not only do they lack significance but the measures for explained variance are also slightly lower than in the conflict onset models. When lagged, drought seems to have a certain impact on conflict intensity, but this is not robust enough to support the hypothesis.

Finally, the last hypothesis explored in this thesis was

H3: the strength of the effect of rainfall variability on conflict depends on level of vulnerability.

This was based on the expectation that the effects of the precipitation variables would be dependent on the values of especially three factors included to measure different non-environmental sides of vulnerability. This was sought measured through interaction terms including rainfall deviation coupled with GDP per capita, ethnic fractionalization and polity. As with the first two hypotheses, there was no support for this in the performed analyses. When included, the interaction terms did not turn out significant. Furthermore, when not included in interaction terms, these measures did not perform in a way consistent with the expectations. This is especially true for GDP, that did not turn out significant at all, and did not act consistently throughout the models. Here, only polity seemed to have an effect on conflict onset, and this effect was generally weak, indicating a slight decrease in conflict risk with a one-unit increase in the polity score.

Summarizing then, the main findings of this thesis are very much in line with that of the general literature in this field of study (see Theisen 2006; Keavane and Grey 2008; Bernauer et al. 2010; Buhaug 2010). No convincing evidence of a correlation between rainfall variability and conflict was found, and the few tendencies in the data that could be interesting to investigate further are far too weak and unstable to provide any sort of support for the three hypotheses posed. The results from the statistical analyses, then, support the findings of the general literature: there is little evidence of a clear link between rainfall variability and violent conflict in Sub Saharan Africa.

6 Conclusion

This thesis has investigated the relationship between climate change, operationalized as rainfall variability, and violent conflict in Sub Saharan Africa. The regression analyses performed in order to study this relationship was motivated by theoretical assumptions regarding the nature of rainfall variability and the nature of conflict, leading to three hypotheses. The first of these states that both positive and negative aberrations in precipitation should be accounted for when the aforementioned relationship is being studied, the second that the effects be stronger for conflict intensity than conflict onset, and the third hypothesis that the effects of rainfall variability be stronger in interaction with measures of vulnerability.

All in all, the findings from the statistical analysis have not been able to confirm the hypotheses that motivated them.

There are mainly two possible explanations for this lack of support. The first is that the findings reflect reality, and that there simply is no clear connection between precipitation patterns and conflict.

This is supported by the fact that my findings are consistent with those of similar studies. In much of the empirical literature in this field, rainfall variability has failed to prove a significant contributor to conflict (Bernauer et al. 2010; Buhaug 2010). This is also true for the measures of hydro meteorological disasters (Theisen et al. 2010; Keavane and Grey 2008). Although climate change may pose a threat to human security, the findings here can not support the view that it may also represent a threat to security when defined in terms of violent conflict risk. The precipitation data that have been in focus here has also been used before, without any significant relationship between these variables and conflict being found. Neither Burke et al. (2009), or Buhaug (2010) found precipitation to be an important contributor to conflict in their respective studies. Choosing a slightly different approach here, and adding variables of hydro meteorological disasters, including interaction terms and using the data on a smaller set of countries, clearly did not shake the ground on which their conclusions rest.

The second possible explanation for the lack of robust findings in this thesis, however, has do to with the characteristics of the research design and of the data; more specifically what is known as measurement error. There are reasons to believe that the data applied in order to find answers to the general research question are not fully capable of doing so. One such reason is that the lack of robust results is not only true for the explanatory variables – but also for the control variables that are very much presumed to be significantly correlated with conflict. For instance, GDP did not give any statistically significant values, nor did it act consistently between the models. However to draw the conclusion that there is no connection between GDP and conflict would not only be opposed to logic reasoning, but also contrary to previous findings and the general established truth. Non – significant findings is not the same as negative findings – it simply means that the answers we are looking for have not been found. I will briefly consider three variants of such measurement errors that may have occurred in this thesis.

First of all**,** it could be that the focus here has been on the “wrong” aggregation level. As recalled, the lack of available data properly matching my theoretical arguments led to certain modifications in the research design compared to the original wishes. In the literature in this field, certain findings do depend on the scale of measurement (Buhaug and Lujala 2005). Although there are solid theoretical reasons to focus on the country level, it remains possible that a lower level of aggregation in the statistical analyses would have changed the conclusions of this thesis. Yet it is especially in regards to the temporal aspect of the precipitation measure, that the solution reached was not fully in accordance with my theoretical arguments. Although using a measure of precipitation as deviation from long-term trend was presumed a better solution than change from previous year alone, it is still not quite good enough **-** the argument that timing is an important element in determining the severity of the effects of rainfall variations was not fully captured by these indicators, as they are still measured on a yearly scale.

Would it have made any difference for my results had I used a different level of aggregation? This question remains hypothetical; yet some inferences can be drawn based on the findings of similar past studies, with both lower level of spatial and temporal aggregation. The former approach is increasingly being tested by scholars, yet does not provide much consistency in terms of findings. On the sub national level, Levy et al. (2005) find some indications of rainfall below normal influencing larger civil wars, while Theisen et al. (2010) find no such link. The latter furthermore corresponds with findings of other studies focusing on the sub national level (Raleigh and Urdal 2007). In regards to a temporal disaggregation, there are to my knowledge few studies in this literature using such an approach. The findings of Meier et al. (2007), using monthly data to investigate climate and pastoral conflicts, had few significant and robust findings. While the authors expect this to be a result of measurement error, it nevertheless leaves me with few empirical reasons to expect that such an approach would have changed my findings. Theoretically, however, the main reasoning behind the wish to use such an approach has not been challenged – annual measures, as used here, do not fully capture the intra annual variations that according to my arguments determine the relative damage of rainfall. Hence even though measures of hydro meteorological disasters partially made up for this, parts of the hypotheses still remains untested.

Secondly, it could be that the lack of significant findings is a result of the number of observations being too small. This is also related to the aspects of the research design that regard data availability. Although the main data has almost 900 observations, which I have argued should be enough to give significant findings, there are few observations with the value 1 on conflict onset; only 46 cases. For conflict intensity, the numbers are not much higher. Hence there may not be enough observations of conflict to give much information about what influences it. A first step to solve this would be to increase the number of observations. Yet, had there been a clear connection between the explanatory variables and the dependent variable as measured here, it would more than likely have given significant results in the analyses. This is backed by the fact that some variables in fact do stay significant and consistent throughout the analysis. Furthermore, to explore the possibility that a higher number of positive observations could have changed the general pattern, a model was tested using conflict incidence as the dependent variable. Having over 200 observations of conflict, however, the explanatory variables still did not turn out neither significant nor consistent. Hence it remains highly uncertain that having more observations would have changed the outcome of the statistical analyses.

The third variant of measurement error to be considered here has to do with data's validity. It is possible that the data simply does not measure what I have expected it to measure**.** The overall low measures of variance informs that the main factors contributing to explain the variance in conflict as defined here, are not present in the models – despite the fact that both GDP and polity are very much assumed to be highly associated with conflict. This casts doubt over to what extent the indicators fully capture what they are meant to capture, hence their validity.

All in all, then, the failure to find support for the hypotheses posed in this thesis might reflect the real world, but it could also be that certain aspects of the research design, especially due to limited data availability, has caused the lack of significant and consistent findings. The failure to find support for the three hypotheses does not, then, warrant the conclusion that the hypotheses – and the reasoning behind them – are proven wrong.

Despite the fact that the main findings were too ambiguous and inconsistent to support the hypotheses, some trends in the results nevertheless prove interesting, especially in regards to the theoretical arguments that motivated the hypotheses. When studying conflict onset, one explanatory variable stayed positive, consistent and statistically significant throughout the analysis; precipitation deviation when lagged two years. While this pattern remains a bit difficult to explain substantially, especially due to the opposite effect being present when the variable is lagged one year, it is nevertheless possible when looking to the neo Malthusian perspective on resource scarcity. It is possible to imagine that the time it takes for rainfall variability to reach violent conflict - through the destruction of cropland, failed crops affecting livelihood, food availability and perhaps the general economy, and the various social grievances that follows this – is approximately two years. This seems especially feasible when keeping in mind that agriculture represents 20 to 30 % of the GDP, makes up 55% of the value of exports and employs about 60 to 90 % of the total work force in Sub Saharan Africa (Brown and Crawford 2009: 10), and that this agriculture is furthermore highly rain – dependent.

Another trend in the findings that is consistent with my arguments is that there are some noticeable differences between Sub Saharan Africa as a whole and East Africa when it comes to the effects of the explanatory variables. The reasoning behind having explored the two separately, is that East Africa follows a different precipitation pattern than the rest of the continent, with more rain being a likely outcome of climate change (Schreck and Semazzi 2004). In the analyses of East Africa, flood turned out significant in about half of the tested models for conflict onset, with consistent, positive values throughout all these tests. This effect was not present when analysing Sub Saharan Africa as a whole. The fact that East Africa, having more rain than the rest of the continent, shows different results could indicate that there are in fact some correlations between excessive rainfall and conflict, that have not been properly captured in this analysis**.** If this is true, then it is likely that there is some sort of threshold effect defining the relationship between the two; hence that the relationship is not linear. While the finding is not robust enough to draw any inferences beyond this, it does nevertheless highlight one of my main arguments in this thesis; that the effects of *more* rain, with emphasis on amount and timing, too should be accounted for when studying the potential effects precipitation has on violent conflict.

The gap between theoretical reasoning and empirical evidence remains, however, this is not to say that the theoretical arguments can be denied. Despite of the lack of support for the hypotheses in this thesis, then, the findings might nevertheless indicate that the arguments presented here regarding the climate change - conflict nexus should be further explored.

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8 Appendix

8.1 Descriptive statistics and correlations

Descriptive statistics for the dependent variables

Variable	Obs	Mean	Std. Dev.	Min	Max
conflict_onset	889	.0517435	.2216335	0	1
conflict_intensity	881	.2474461	.6252788	0	2

Correlation matrix conflict onset, original variables

	Onset	Dev.	Dev.1	Dev.2	Flood	Drought	GDP	Ethnic	pol	lpop
Onset	1									
Deviation	0.021	1								
Deviation1	0.011	0.325	1							
Deviation2	0.088	0.109	0.278	1						
Flood	0.033	0.189	0.030	0.010	1					
Drought	-0.018	-0.022	0.094	0.101	0.038	1				
GDP	-0.047	0.073	0.076	0.040	-0.075	0.050	1			
Ethnic	0.035	0.019	0.002	0.010	0.081	-0.025	-0.411	1		
PolitySQ	-0.130	-0.015	0.006	-0.015	-0.143	0.0265	0.312	-0.248	1	
Lpop	0.014	0.013	0.033	0.079	0.296	0.0398	-0.307	0.327	-0.240	1

Correlation matrix conflict onset, recoded variables

	Onset	Dev	Dev.1	Dev.2	Flood	Droug.	GDP	Pol	Ethn.	lpop
Onset	1									
Deviation	0.009	1								
Deviation1	-0.042	0.318	1							
Deviation2	0.038	0.246	0.315	1						
Flood	0.033	-0.010	-0.038	-0.005	1					
Drought	-0.018	0.096	-0.002	-0.016	0.038	1				
GDP	-0.038	0.124	0.095	0.089	-0.077	0.046	1			
PolitySQ	-0.116	0.039	0.030	0.049	-0.111	0.014	0.340	1		
Ethnic	0.028	-0.068	-0.049	-0.063	0.044	-0.036	-0.315	-0.185	1	
Lpop	0.014	-0.271	-0.261	-0.250	0.296	0.040	-0.323	-0.214	0.217	1

Correlation matrix conflict intensity, original variables

	Intensity	dev	Dev1	Dev2	Flood	Drought	GDP	Ethnic	Polity	Lpop
Intensity	1									
Deviation	-0,013	1								
Deviation1	0.000	0.326	1							
Deviation2	0.036	0.107	0.278	1						
Flood	0.016	0.191	0.032	0.008	1					
Drought	0.051	-0,022	0.095	0.100	0.030	1				
GDP	-0,098	0.074	0.077	0.041	-0,08	0.052	1			
Ethnic	0.066	0.020	0.001	0.011	0.082	-0,024	-0,415	1		
PolitySQ	-0,096	-0,018	0.007	-0,02	-0,15	0.022	0.317	-0,246	1	
Lpop	0.176	0.014	0.034	0.070	0.293	0.037	-0,308	0.329	-0,243	1

Correlation matrix conflict intensity, recoded variables

	Intens.	Dev	Dev1	Dev2	Flood	Drought	GDP	Poli.	Ethn.	Lpop
Intensity	1									
Deviation	-0,013	1								
Deviation1	-0,032	0.320	1							
Deviation2	-0,010	0.245	0.317	1						
Flood	0.016	-0,012	-0,038	-0,001	1					
Drought	0.051	0.093	-0,002	-0,013	0.030	1				
GDP	-0,105	0.127	0.098	0.092	-0,079	0.049	1			
PolitySQ	-0,118	0.039	0.0257	0.052	-0,114	0.012	0.345	1		
Ethnic	0.0490	-0,067	-0,045	-0,065	0.049	-0,033	-0.321	-0,181	1	
Lpop	0.176	-0,275	-0,262	-0,249	0.293	0.037	-0.329	-0,214	0.219	1

8.2 Do file

****

***********************GETTING STARTED*************************

set mem 100m

use "M:\Stata\Main.dta", clear

rename conflict conflict_incidence

rename onset2 conflict_onset

tsset ccode year, yearly

****

**************PREPARING THE VARIABLES**********************

****generating new versions of the variables**

***making square polity, and making new polity**

gen pol_sq = polity2^2

gen polsq_new = pol_sq

recode polsq_new (0/25 = 1) (26/50 = 2) (51/75 = 3) (76/100 = 4)

***making new ethnic variable, 4 categories**

gen ethnic_new = al_ethnic

recode ethnic_new(0/.25 = 1) (.2501/.4999 = 2) (.5/.7499 = 3) (.75/1 = 4)

***making new gdp, 4 categories**

gen gdp_new = l_gdp

recode gdp_new (5.1/6.2 = 1) (6.2005/7.3 = 2) (7.3001/8.4 = 3) (8.4001/9.7 = 4)

*** making deviation with 4 categories**[12]

gen PreDev_new = cprec_dev

recode PreDev_new (-.15/.15 = 1) (-.399/-.1501 = 2) (.1501/.399 = 2) ///

(-.749/-.4 = 3) (.4/.749 = 3) (.75/3 = 4)

***repeating for the lagged precipitation variables**

gen PreDev1_new = cprec_dev1

recode PreDev1_new (-.15/.15 = 1) (-.399/-.1501 = 2) (.1501/.399 = 2) ///

(-.749/-.4 = 3) (.4/.749 = 3) (.75/3 = 4)

gen PreDev2_new = cprec_dev2

recode PreDev2_new (-.15/.15 = 1) (-.399/-.1501 = 2) (.1501/.399 = 2) ///

(-.749/-.4 = 3) (.4/.749 = 3) (.75/3 = 4)

*** making vulnerability index**

gen vuln_ind = gdp_new + polsq_new + ethnic_new

********************** Making interaction terms***************************

******making interactions with original variables**

gen int_dev_pol = cprec_dev* pol_sq

gen int_dev_etn = cprec_dev* al_ethnic

gen int_dev_lgdp = cprec_dev* l_gdp

*****making interaction terms for recoded variables**

gen int_d_gdp = gdp_new*PreDev_new

gen int_d_etn = ethnic_new*PreDev_new

[12] The same operation has been done for precipitation change

gen int_d_pol = PreDev_new* polsq_new

gen int_d1_gdp = PreDev1_new* gdp_new

gen int_d1_pol = PreDev1_new* polsq_new

gen int_d1_etn = PreDev1_new* ethnic_new

gen int_d2_etn = PreDev2_new* ethnic_new

gen int_d2_pol = PreDev2_new* polsq_new

gen int_d2_gdp = PreDev2_new* gdp_new

***making inteaction with reversed gdp**

gen temp = gdp_new

label variable temp "reversed gdp new"

recode temp (1=4) (2=3) (3=2) (4=1)

gen int_tgdp_dev = temp* PreDev_new

label variable int_tgdp_dev "interaction dev new and reversed gdp new"

***generating interactions vulnerability index and each of the new deviations**

gen int_ind = vuln_ind* PreDev_new

gen int_ind1 = vuln_ind* PreDev1_new

gen int_ind2 = vuln_ind* PreDev2_new

*** making the intensity variable**

gen intensity = .

recode intensity .=1 if conflict_onset == 1 & war_prio_new ==0

recode intensity .=2 if conflict_onset == 0 & war_prio_new ==1

recode intensity .=0 if conflict_onset == 0 & war_prio_new ==0

****

****************** **CORRELATIONS** ***************************

```
set mem 100m

use "M:\Stata\Main.dta", clear
```

***Variable Correlations for main models**

```
corr  conflict_onset cprec_dev cprec_dev1 cprec_dev2 flood drought l_gdp ///
al_ethnic  pol_sq lpop

corr  conflict_onset PreDev_new PreDev1_new PreDev2_new flood drought ///
gdp_new polsq_new ethnic_new lpop


corr  intensity cprec_dev cprec_dev1 cprec_dev2 flood drought l_gdp al_ethnic ///
pol_sq lpop

corr  intensity PreDev_new PreDev1_new PreDev2_new flood drought  gdp_new ///
polsq_new ethnic_new lpop
```

***Variable correlation for main models, East Africa**

```
drop if ccode<=499

drop if ccode==571

drop if ccode==570

drop if ccode==580

drop if ccode==541

drop if ccode==565

drop if ccode==560

drop if ccode==551

drop if ccode==552

drop if ccode==572

drop if ccode==540
```

drop if ccode==553

corr conflict_onset cprec_dev cprec_dev1 cprec_dev2 flood drought l_gdp ///
al_ethnic pol_sq lpop

corr conflict_onset PreDev_new PreDev1_new PreDev2_new flood drought ///
gdp_new polsq_new ethnic_new lpop

corr intensity cprec_dev cprec_dev1 cprec_dev2 flood drought l_gdp al_ethnic ///
pol_sq lpop

corr intensity PreDev_new PreDev1_new PreDev2_new flood drought gdp_new ///
polsq_new ethnic_new lpop

***Model correlations [13]**

logistic conflict_onset cprec_dev cprec_dev1 cprec_dev2 drought flood al_ethnic ///
l_gdp pol_sq lpop

vce

logistic conflict_onset PreDev_new PreDev1_new PreDev2_new flood drought ///
gdp_new polsq_new ethnic_new lpop

vce

ologit intensity cprec_dev cprec_dev1 cprec_dev2 flood drought l_gdp al_ethnic ///
pol_sq lpop

vce

ologit intensity PreDev_new PreDev1_new PreDev2_new flood drought gdp_new ///
polsq_new ethnic_new lpop

vce

[13] Main models demonstrated only

****

********************REGRESSION MODELS***************************

*********The tables demonstrated in the thesis*******

*****Logistic regression for conflict onset**[14]

```
set mem 100m

use "M:\Stata\Main.dta", clear


*Tables 1 and 2

logistic conflict_onset   cprec_ch cprec_ch1 cprec_ch2 flood drought  l_gdp ///
 al_ethnic pol_sq lpop

outreg2 using table1, 2aster nolabel word bdec (3) alpha (0.05, 0.1) replace


logistic conflict_onset    cprec_dev cprec_dev1 cprec_dev2 flood drought  l_gdp ///
al_ethnic pol_sq lpop

outreg2 using table1, 2aster nolabel word bdec (3) alpha (0.05, 0.1) append


logistic conflict_onset  cprec_dev1 cprec_dev2 flood drought  l_gdp al_ethnic  ///
pol_sq int_dev_lgdp lpop

outreg2 using table1, 2aster nolabel word bdec (3) alpha (0.05, 0.1) append


logistic conflict_onset PreDev1_new PreDev2_new flood drought gdp_new ///
ethnic_new polsq_new int_d_gdp lpop

outreg2 using table1, 2aster nolabel word bdec (3) alpha (0.05, 0.1) append


logistic conflict_onset  PreDev_new PreDev1_new PreDev2_new flood drought ///
gdp_new  ethnic_new polsq_new  lpop

outreg2 using table1, 2aster nolabel word bdec (3) alpha (0.05, 0.1) append
```

[14] The command "logistic" was used to get the coefficients as odds ratios, however in the *outreg* tables they are demonstrated as log odds

*** East Africa (Table 2 has the same operations as table 1)**

drop if ccode<=499

drop if ccode==571

drop if ccode==570

drop if ccode==580

drop if ccode==541

drop if ccode==565

drop if ccode==560

drop if ccode==551

drop if ccode==552

drop if ccode==572

drop if ccode==540

drop if ccode==553

***** Ordered logistic regressions for conflict intensity**

set mem 100m

use "M:\Stata\Main.dta", clear

***Tables 3 and 4**[15]

ologit intensity cprec_ch cprec_ch1 cprec_ch2 flood drought l_gdp al_ethnic ///
pol_sq lpop

outreg2 using table3, 2aster nolabel word bdec (3) alpha (0.05, 0.1) replace

ologit intensity cprec_dev cprec_dev1 cprec_dev2 flood drought l_gdp al_ethnic ///
pol_sq lpop

outreg2 using table3, 2aster nolabel word bdec (3) alpha (0.05, 0.1) append

[15] The same operations, but for the East African countries as shown under table 2.

ologit intensity cprec_dev1 cprec_dev2 flood drought l_gdp al_ethnic pol_sq ///
int_dev_lgdp lpop

outreg2 using table3, 2aster nolabel word bdec (3) alpha (0.05, 0.1) append

ologit intensity PreDev1_new PreDev2_new flood drought gdp_new ethnic_new ///
polsq_new int_d_gdp lpop

outreg2 using table3, 2aster nolabel word bdec (3) alpha (0.05, 0.1) append

ologit intensity PreDev_new PreDev1_new PreDev2_new flood drought gdp_new ///
ethnic_new polsq_new lpop

outreg2 using table3, 2aster nolabel word bdec (3) alpha (0.05, 0.1) append

**************Some of the models not included in the tables[16] **************

set mem 100m

use "M:\Stata\Main.dta", clear

tsset ccode year, yearly

logistic conflict_onset PreDev1_new PreDev2_new flood drought l_gdp pol_sq ///
al_ethnic lpop if PreDev_new == 1

logistic conflict_onset PreDev1_new PreDev2_new flood drought l_gdp pol_sq ///
al_ethnic lpop if PreDev_new == 2

logistic conflict_onset cprec_dev1 cprec_dev2 flood drought al_ethnic l_gdp ///
pol_sq lpop if cprec_dev<=0

logistic conflict_onset cprec_dev1 cprec_dev2 flood drought al_ethnic l_gdp ///
pol_sq lpop if cprec_dev>=0

[16] The same operation was executed on both East Africa and for the intensity variable using the ”ologit” command rather than “logistic”

```
logistic conflict_onset  cprec_dev cprec_dev1 cprec_dev2 flood L.drought l_gdp ///
al_ethnic pol_sq lpop
```

```
logistic conflict_onset  cprec_dev cprec_dev1 cprec_dev2 flood L2.drought l_gdp ///
al_ethnic pol_sq lpop
```

```
logistic conflict_onset  cprec_dev cprec_dev1 cprec_dev2 L.flood drought l_gdp ///
al_ethnic pol_sq lpop
```

```
logistic conflict_onset  cprec_dev cprec_dev1 cprec_dev2 L.flood L.drought l_gdp ///
al_ethnic pol_sq lpop
```

```
logistic  conflict_incidence  cprec_dev cprec_dev1 cprec_dev2 flood drought l_gdp///
al_ethnic pol_sq lpop
```

*** Making Sub Saharan Africa excluded East Africa**

```
drop if ccode==516
drop if ccode==522
drop if ccode==530
drop if ccode==501
drop if ccode==517
drop if ccode==520
drop if ccode==625
drop if ccode==500
drop if ccode==510
```